93

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THE INFLUENCE OF ULTRA-VIOLET RAYS, X-RAYS AND TEMPERATURE ON THE GERMINATION OF ZEA MAYS

BY

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INDEX.

		Page
1.	Introduction	1
2.	Review of literature	2
	(*a*) Effect of Ultra-violet radiation	2
	(*b*) ,, ,, X-rays	6
	(*c*) ,, ,, temperature	7
3.	Materials and methods	9
	(*a*) The selection of the seeds	9
	(*b*) Ultra-violet rays and their measurements and exposure	10
	(*c*) X-rays and its application	11
	(*d*) Constant temperature bath and procedure of treating seeds	11
4.	Discussion of Data	13
	(*a*) Effect of Ultra-violet rays on seeds ...	13
	(*b*) ,, ,, X-rays on seeds	14
	(*c*) ,, ,, Temperature on seeds	18
5.	Summary	21
6.	Acknowledgement	21
7.	Literature cited	21

Introduction.

The recent advances in physics and chemistry have opened up many physiological problems, which command both practical and theoretical applications. Within the last 15 years interest has been

shown in the various qualities and quantities of radiation on the functions, structures and changes that may take place in organisms. This study is confined, in a large measure, to lower animals and plants such as fungi and bacteria, because they respond more effectively, immediately and specifically. One would expect this behavior from lower organisms since more of their unit surface and area are exposed to the surroundings. Yet higher plants are also influenced, particularly in respect to their growth.

There are some experiments on record, which show the effect of various kinds of radiations on plants. However, there are only a few experiments performed in which the effect of various radiations on dry seeds has been studied. It was, therefore, proposed to learn what influence different dosage of ultra-violet rays and X-rays might have on the corn seeds. Any information gained from these findings, may be helpful in the physiology of germination. Since the degree of temperature seems to be of some influence in the quality and the rate of germination, some experiments in this connection were also conducted.

Review of Literature.

(a) *Effect of Ultra-violet radiation.*

The effects of light on organisations are of great importance. It seems from recent work that the fundamental principles as to how light affects protoplasm may more readily be studied by working with light of shorter wave lengths than by investigating the effect of longer wave lengths as they occur in sunlight, because the light of smaller ranges affects more effectively and rapidly, both physically and chemically. Such effects of Ultra-violet light (as we know now) were noted even in the nineteenth century (although they did not isolate such rays). For instance, Vallet (1814) cured a case of dropsy by exposing the patient to sunlight and Löbel (1815) treated a patient of amaurosis by focusing sunlight upon the diseased eye, recognizing not only the physical but also the chemical effect of sunlight and heat. Charcot (1858), however, definitely noted the chemical action of sunlight. Similarly Downes and Blunt (1877, 1878), Duclaux (1885) and Roux (1887) recognised such an effect on some small organisms.

There is evidence that chemical characters of some of the elements are changed under the influence of ultra-violet rays. For instance, oxygen forms an ozone, which is more stable than oxygen. This phenomenon is of particular interest to a physiologist, because ozone is more opaque to short light waves than the molecular oxygen. Since ozone is generally found in the atmosphere of the upper layers,

it acts as a filter against ultra-violet rays of the sun, thus protecting the organisms of the earth from these shorter and more destructive rays.

Protoplasm contains many photosensitive elements and substances, which decompose when exposed to ultra-violet rays. Decomposition may take place in dry materials or in a vacuum. Bovie (1913) found that the time required to kill spores of fungi was the same, whether the spores were exposed while in a high vacuum, in air or when turgid with imbibed water. This result is most surprising in view of what is known of biochemical reactions, all of which take place in aqueous media. Dreyer and Hanssen (1907), Burge (1914) and Henri (1912) showed, that albumins and globulins are coagulated when exposed to ultra-violet radiations. The latter author measured the relative destructive action of light of various wave lengths. He found, that, in general, destructive action of light increases continuously as the wave length decreases. Bovie (1916) agrees with Henri's (1912) conclusions based on his study of Spirogyra. Furthermore, he has presented an excellent summary, especially of the older literature. Victor Henri (1902) found time and wave length value for absorption of rays by organisms.

Numerous authors such as Sheard and Johnson (1930), Eltinge (1928), Gibbs (1927), Fulton (1929), and Stevens (1928) have studied the effect of ultra-violet rays on higher and lower plants. These authors report different results, namely, that some found beneficial and stimulating effects, while the others indicated harmful and injurious responses by the plants. There are many factors involved, to which varying results may be attributed. These factors will be more clearly brought out in the following paragraphs.

Tanner and Ryder (1923) studied the effect of ultra-violet light on yeast-like fungi. They did not find any evidence which would indicate that yeast cells possesses any marked resistance to this type of radiation. In their experiments, the cells lived only from a few seconds to a few minutes longer than bacteria. They explain such a difference as due to their size variations. They also found that pigmented yeasts are more resistant than white ones. This is probably due to their resistance against penetration of the rays. They seem to conclude, that there is a direct relation between the size of the cell and its resistance against the injurious effect of ultra-violet light.

Fabricius (1928) made comparative germination tests of seeds under ordinary glass and under a special glass which would transmit ultra-violet rays. He concludes that spruce germination may be considerably hastened by ultra-violet rays when applied during late winter; however, the final percentage of germination did not increase. On the other hand, the more intense ultra-violet rays, delayed germi-

nation when they were applied in spring. For pine, the effect was insignificant, although a similar tendency was also shown ; while larch germinated quicker with larger final percentage both in winter and spring. The author, however, remarks that these results were obtained only when new apparatus was used, because the old equipment seemed to show results quite contrary to the ones described above.

Dunin (1928) in Russia studied germination of Hibiscus cannabinus with reference to temperature, hydrogen ion concentration and light. He did not find any effect of diffused light on germination.

Stevens (1928) exposed various fungi to different ranges of ultra-violet rays for variegated time periods. He found that the effective wave lengths ranged from 313 u. u. to 80 u. u. In his studies, different strains of Glomerella reacted very differently to radiation. More recently Ramsey and Bailey (1930) studied similar effect upon sporulation in Macrosporium and Fusarium. They found slight stimulation effect when the light range was not lower than 3120 A.u., but those whose lower limits were 3334 A.u. or above were not effective. With wave lengths of 2535 A. u. and shorter, they noted some lethal effect and inhibition of myçelial development.

From the conclusions drawn by Stevens (1928) and Ramsey and Bailey (1930) with reference to the growth of fungi in culture media, it may be asked if these organisms are stimulated or inhibited directly or by the action of ultra-violet radiation first on the culture media and consequently on the organisms. Woodrow, Bailey and Fulmer (1927) studied the effect of this range of radiation upon yeast culture media. They found that, on exposure to ultra-violet rays, the medium developed a toxicity, which increased with the length of the time of irradiation.

Jacobi (1928) observed the effect of ultra-violet light (400–300 u. u.) both in germinating and air dried seeds. He found stimulative effect both in germination and growth. He seems to have found the maximum sensitive effect during the embryo germination. The air dried seeds showed very low sensitivity. Very long exposures, however, seemed to inhibit germination.

Gibbs (1926) found, that only radiation less than 3126 A.u. is toxic to Spirogyra. Such an exposure, from 1 to 7 minutes at 16 c.m. is usually fatal. It first damages chlorophyll. The same seems to hold for higher plants, since Dane (1927) working with soy beans found that the longer the ultra-violet exposure was given, the shorter the plant grew. In other words, ultra-violet rays inhibited growth. Popp and Brown (1927–28) also found harmful effects with 15 minutes daily exposures. They used radish seeds and seedlings for their experiments.

Fulton and Coblentz (1929), Coblentz, Recklinghauson (1914), Fulton (1924), Ward (1893, 1895), Burge (1915) experimentally demonstrated the effectiveness of ultra-violet rays as a germicide. A patent was issued to Recklinghausen (1915) to that effect. Popp (1926) studied the physiological effect of light of various ranges of wave length on the growth of higher plants. His result as a whole indicates that, while ultra-violet rays are not indispensable, the blue violet end of the spectrum is necessary for normal vigorous growth of plants.

Browning and Russ (1917) found germicidal action between 238 and 294 u. u. An exposure of 3½ hours showed the limits of germicidal action to be 215 u. u. and 296 u. u. Radiations between 296 and 380 u. u. exhibited no effect on germs, but they were found to penetrate the human skin for an appreciable depth.

In seeds, the harmful or beneficial effect, not only may be due to the effect on the protoplasm but also on the enzymes. It has been shown by Chauchard and Mazone (1911), that the two enzymes amylase and invertase, suffered the loss of their activities when exposed at a distance of 12 c. m. from a quartz mercury arc. Rgulhon (1911) has suggested that enzymes may be divided into three classes according to their sensitiveness to radiation. In the third type, their activity is destroyed by ultra-violet radiation. Chauchard (1913) found that radiations between 220 and 250 u. u. destroyed the action of lipase. He later (1914) found that amylase was appreciably impared by rays of 280 u. u. in wave length.

Verhceff and Bell (1916) found that it is the radiation shorter than 305 u. u. which is able to injure cells by chemical action According to these authors, there is a practical limit to the injurious effect of ultra-violet rays, for the influence of radiation of longer wave lengths than 305 u. u. is so slight that it could be overpowered by the physiological activities of the cells under ordinary circumstances. This may be true of plants as well as of animals. It seems certain from the researches of many animal workers that, the radiations most effective in causing sunburn, irritation and in fact, the destruction of animal tissue, are chiefly confined to the middle ultra-violet region. Schurck (1918) exposed the forearm to ultra-violet rays and found that the greatest effect lies in the region of 235 to 250 u. u., although the region was indefinite. Henri and Moycho (1914) exposed the ear of a rabbit and found harmful effects from 230 to 330 u. u.

Shanz (1919) considers that the radiation of shorter wave lengths appears to take less part in assimilation, although it is otherwise chemically more effective. In respect to ultra-violet rays, he concludes

that, owing to the greater absorption of the radiation of the shorter wave lengths by the plant material, these rays are less effective. Recently Luckiesh (1922) has thoroughly summarized this whole subject.

From the review presented thus far, with reference to the effect of ultra-violet rays on plants, it would seem that, most of the results are, indefinite. It may also be concluded that much of the work had been done with either bacteria, fungi or algae. However, where higher plants have been used, the main emphasis has been laid upon the plant itself or on the germinating seeds. With the exception of two cases, so far as the writer is concerned, there is no record available, in which dry seeds may have been used.

(b) *Effect of X-rays.*

In a field, where it might be expected that X-radiation would be of great importance, namely, that of inducing chemical and biological reactions, surprisingly little definite quantitative information has been gained as noted by Clark (1927). Dauvillier (1925) has postulated, that biological reactions are proportional to the energy absorption regardless of the wave lengths. Clark (1927) in reviewing the work of Collwell and Russ, reports on the conversion of starch into dextrin by X-rays. Fernau (1923) inverted cane sugar solutions by X-radiation.

On the other hand, there are some reactions which, while greatly accelerated by light, are unaffected by X-rays. In this connection, Clark, Mead and Cochrane's (1925) work may be referred to.

Most studies employing the use of X-rays were undertaken to bring about the genetic modification. However, there are a few investigations where stimulating or depressing effects have also been studied. The manner in which germination and growth are influenced by these rays is still a subject of disagreement, as is shown below.

Altman, Rochlin and Gleichgewicht (1923), Koernicke (1904) and Petry (1922) studied the effect of X-rays on higher plants. They report that a weak irradiation causes a positive stimulation, since they found acceleration of growth. On the other hand, Halberstaedter and Simons (1923), Jungling (1920) and Koernicke (1904) find a temporary checking of growth followed by an acceleration. Johnson's (1926), (1928) extensive experiments seem to show that plants from irradiated seeds show no increase in total growth either at an early or a late stage. She used both air dry and soaked seeds. She clearly points out in her summary that irradiation of sunflower seeds by X-rays does not result in increased rate of germination, increased percentage of germination, increased growth during the early seedling stages or in increased height and weight at maturity.

Miss Johnson also mentions that, seeds in air dry condition are much less susceptible to the harmful effect of X-rays, than are those which have a water content above 50 per cent. With reference to such an effect on different species, she remarks that they show differential injury when exposed to the same dosage and to the same environmental conditions.

Ancel (1926) studied the injury produced by X-rays on dry seeds. He found that strong doses produce a lesion in latent seed. He concludes that a distinct lesion of medium or strong X-ray intensity caused by exposing dry bean seeds is retained entirely for some time after the exposure under the dosage of his conditions (200 H. 190 H. and 100 H). However, he used only 70 dry seeds, which number is not a large one to base one's conclusions. This fact has also been pointed out by Bersa (1926).

Patten and Wigoder (1929) exposed various kinds of seeds chiefly broad beans, barley and mustard to X-rays. They used 120 kilovolts, which dose is approximately 3 times that required to redden human skin. Dry seeds also were used. All seedlings were stunted. Broad beans appeared to be more sensitive. In mustard seeds, exceedingly small doses seemed to cause more rapid growth.

It is asked sometime whether higher organisms may not be less influenced by X-rays than smaller organisms. The experimental work seems to show evidence contrary to this view. Schneider (1926) observed that unicellular organisms are less sensitive to X-rays than higher ones. He explains this by the fact that the individual cell in a unicellular organism is far more independent of its surroundings than a cell in association with others as in the case of multicellular organisms.

Interesting experiments were conducted by Ancel (1928) as to the effect of fractional doses of X-rays on germinating seeds. When he divided the dosage between two exposures, there was decidedly less injury than from an equivalent dose given at one exposure. He found similar results from 18 exposures of 40 germinating lentil seedlings each. He (1924, 1925) in another experiment, employed more than 16,000 dry seeds of many kinds. He used doses varying from 1/12 to 20 units. He could not notice any hastening in the germination by such doses.

In summarising the effect of X-rays on plants, in general, and seeds in particular, as reviewed in the foregoing paragraphs, it may be concluded that results, in the main, are dissimilar. There seems to be a need of further work in this connection.

(c) *Effect of temperature* :

The effect of temperature on the germination and growth has already received a great deal of attention. Jost (1921) remarks in

Strasburger's botany, that there is a complete cessation of growth at a temperature less than 0°C. or higher than 40°C.-50°C. The optimum temperature, according to him, lies between 22° and 37°C.

Maximov (1930) remarks, that like all other vital processes, growth to a considerable degree depends on temperature; being accelerated by a rise, and retarded by a decrease. However, various plants are not identical in this respect. He reproduces Haberlandt's table for the germination of seeds including maize as to their maximum, optimum and minimum temperatures. Maize requires 5–10°C. minimum, 37°–44°C. optimum and 44°–50° maximum temperature to germinate. Maximov further brings out, that winter cereals show a pronounced need of cold temperature, at least in their early germination and growth.

Many authors such as Crocker (1916), Crocker and Harrington (1918), Howard (1915), have shown that by exposing seeds to low temperatures, their dormancy and rest period can be broken, which may hasten their germination. Crocker and his associates found a temperature of about 5°C. the best at which to hold seeds of Rosaceae.

Davis and Rose (1912) working with Crataeyus mollis, found that ordinarily seeds do not germinate. However, if they were kept moist from the time of removal from the carpels and held at 5° to 6°C., they would germinate in a much shorter time. When they exposed them to temperature as low as – 2°C., the progress was stopped. Stratification, a common pratice of nurserymen is also based on alternately exposing the seeds to fluctuating temperatures. Tukey in this connection (1924) did not find freezing beneficial after ripening. In fact, it was found injurious sometimes.

According to Barton Wright (1930) if the temperature be too low, germination fails to occur, if too high, the seed may be permanently injured and killed. The temperatures at which different seeds germinate, are different. He has enumerated several examples to that effect. He speaks of germinating seeds and not of air dried seeds, as used in this study.

Morinaga (1926) used alternate high and low temperatures for seeds of a number of species. He found divergent results. Almost similar conclusions were reached by Wilson (1928) who recommends for wheat, 15°C., soy beans, 25°C. and for oats, 25–30°, in order to obtain constant tests.

Kienholz (1924) studied effects of high temperatures on germination. He found that air dry corn was killed by exposures to 80°C. for 25 minutes, to 90°C. for 10 minutes and injured by exposure to 70, 80 and 100°C. for 80, 10 and 5 minutes respectively. He

found that resistance to heat varied inversely as water content. The lethal effect of higher temperatures seems reasonable, since Lepeschkin (1929) has shown that proteins and lipoids are very unstable and can be decomposed by chemical, physical and mechanical agents.

Hoffman (1928) tested the effect of heat on the seeds of several forest trees by subjecting them to dry heat ranging from 100° to 240°F. He found that Douglas fir and Western white pine seeds were not only highly resistant to heat but also much more resistant than those of silver and noble firs. In general, moist heat was more destructive to viability than was dry heat.

Coffman's (1923) work shows that seeds of different species germinate at different temperatures. From his results, he recommends the use of lower temperatures for the germination of alfalfa, clover and cereals than those employed in the seed testing laboratories.

Gain (1927) reports interesting results. He showed that seeds of diverse oil producing plants can endure a high temperature (60°C. for several months, also 100°C.), without losing the capacity for germination or for complete development. The sunflower is able to germinate after the embryo is isolated, desiccated and heat up to 155°C.

Kamensky (1928) attempted to stimulate germination of seeds with boiling water. He disagrees with the old work (but agrees with the later work) that germination cannot be stimulated by treating seeds with boiling water. After treatment, the embryos of some of them (Phacelia tanacetifolia and Cannabis sativa) are often forced out by soaking but that is false germination.

Kotowski (1926) has produced data which show, that speed of germination for all species increases in accordance with rising temperature, but certain cold resistant kinds, namely, spinach, lettuce, cabbage, beets and parsley give high germination at lower temperature. He used temperatures of 39.2, 46.4, 51.8, 64.4, 77 and 86°F.

There are many other studies, which record the effect of temperatures on seeds. However, the few reviewed already are enough to indicate the general behaviour of seed protoplasm under various thermal effects. One may ask, "Is dry protoplasm or at least protoplasm with lower water content as possessed by dry seeds, affected by higher and lower temperatures?" If it does, what factors can modify it? Enquiries to these questions have been made in this and the following articles.

Materials and Methods.

(a) The selection of the seeds.

Uniform ears of Golden Bantan and Shawnee white varieties of corn were secured from the "Farmers' Union Coöperative Business

Association," St. Mary's, Kansas. All ears were picked from the same field a year previous to their treatment and germination. These varieties were selected because (1) they are grown locally, (2) they have been reported to yield high germination, at least in the environment of middle Kansas, (3) they bear heavy crops, (4) the grains appeared to be more or less uniform and (5) this crop is of great economic importance in the middle western states of the United States of America.

In this study, seeds from the middle portion of an ear were used. It was assumed that grains secured from the tip or butt ends make denormal or abnormal development. The result of such a process may cause uneven germination. In fact, this was actually found experimentally. The seeds were weighed in lots of 100 each. An attempt was made to have the weights of different lots as close as possible. Four lots (400 seeds) of each variety were used for each treatment, making a total of 22,400 seeds.

(*b*) Ultra-violet rays were secured from a Cooper-Hewitt quartz mercury arc-lamp. The lamp was illuminated by means of direct electric current of 4 amperes at 110 volts. Exposures were made at a distance of 40 c.m. from the arc. Uviol glass screen was used. This would permit rays of a wave length of 253 u. u. as noted by Ellis and Wells (1925). This wave length indicates a middle or intermediate region of ultra-violet light. The accuracy of this wave length was first ascertained by means of a spectrograph, using the same screen as used in the experiments. Negatives were exposed and the wave length was tested.

The use of such a wave length (253 u. u.) was preferred, because it is the middle region. It has been shown by animal as well as plant physiologists that extreme region with wave lengths of O to 200 u. u. is, in general, harmful to living organisms; while the region of ultra-violet rays with a wave length of 300–390 u. u. is, in general, either beneficial or ineffective. It is the middle region where the data are scarce, with particular reference to dry seeds, whose study was proposed in these experiments.

The seeds were exposed on a glass plate, care being taken that all were equally affected. The side with the embryo was exposed, since it was realized that the embryo may be more sensitive to the treatment than the endosperm. The seeds were exposed to various durations of time. The time was regulated by an accurate stop-watch. Since the lamp furnishes a great amount of heat, a fan was blown to drive away as much heat as possible. Such a precaution was particularly necessary for longer exposures. At no time the temperature exceeded 35°C., which is not harmful. Seeds were also exposed to straight arch.

The treated seeds were allowed to cool. After 2 days they were germinated, the percentage computed, and the data analysed by Fisher's (1928) statistical methods.

(*c*) X-rays were obtained from the Victor filament Controller. This X-ray outfit was manufactured by General Electric X-ray Corporation, Chicago, Illionis. The tube for the source of the rays, was placed 25 inches from the seeds.

First the intensity of X-rays was measured. There are several methods used for the measurement of X-ray intensity, namely, heat method, ionization method, photographic method, fluorescent method, selenium-cell method and coloration method. In this study the last of these methods was used. Barium platinocyanide "pastille" was placed at a distance of 25 inches from the anticathode of the tube. The pastille changed its color from yellow green to brown and was matched against a set of standards. The periodic comparison indicated the total energy absorbed. The method does not give an accurate quantitative information, because wave lengths of all kinds are measured by a surface color change. However, it is probably the simplest method to work with. Furthermore, in medical treatment, it is used very often as an index of X-ray intensity as recorded by Kaye (1923). When a beam of X-rays fell upon the seeds it scattered. Such a phenomenon has been illustrated in figure I.

The seeds were exposed on a glass plate in exactly the same manner as used in the ultra-violet radiations. Different exposures were given. Since there was no cooling device connected with the outfit, the longer exposures were divided into doses of 15 seconds each. This was done for all exposures exceeding 1 minute. The seeds were germinated, counted and analysed as before.

(*d*) Experiments on temperature were conducted in two sections. All seeds treated with a temperature of 30°C. or over, were put in a large pyrex test tube, which was suspended in DeKhotinsky electrically heated and regulated thermostat bath. This bath was constant to one tenth of a degree centigrade. It was provided with immersion heaters and Turbine stirrer. The stirrer could take water from the bottom of the bath at the rate of about 5 liters a minute. In every case distilled water was used to avoid any sedimentation at the bottom of the bath.

For temperatures below 20°C. cooling coils were used. These coils replaced the heaters, operated previously. For freezing temperatures and below, Beckman's freezing apparatus was used. In every case, seeds were suspended in test tubes. They were kept for two hours. As far as it was possible, seeds were not crowded, so that their maximum surface might be exposed to various temperatures.

After respective treatments, the seeds were allowed to adjust to the laboratory environment, germinated in petri dishes as usual and placed in an incubator, which was maintained at 25°C. Germinated

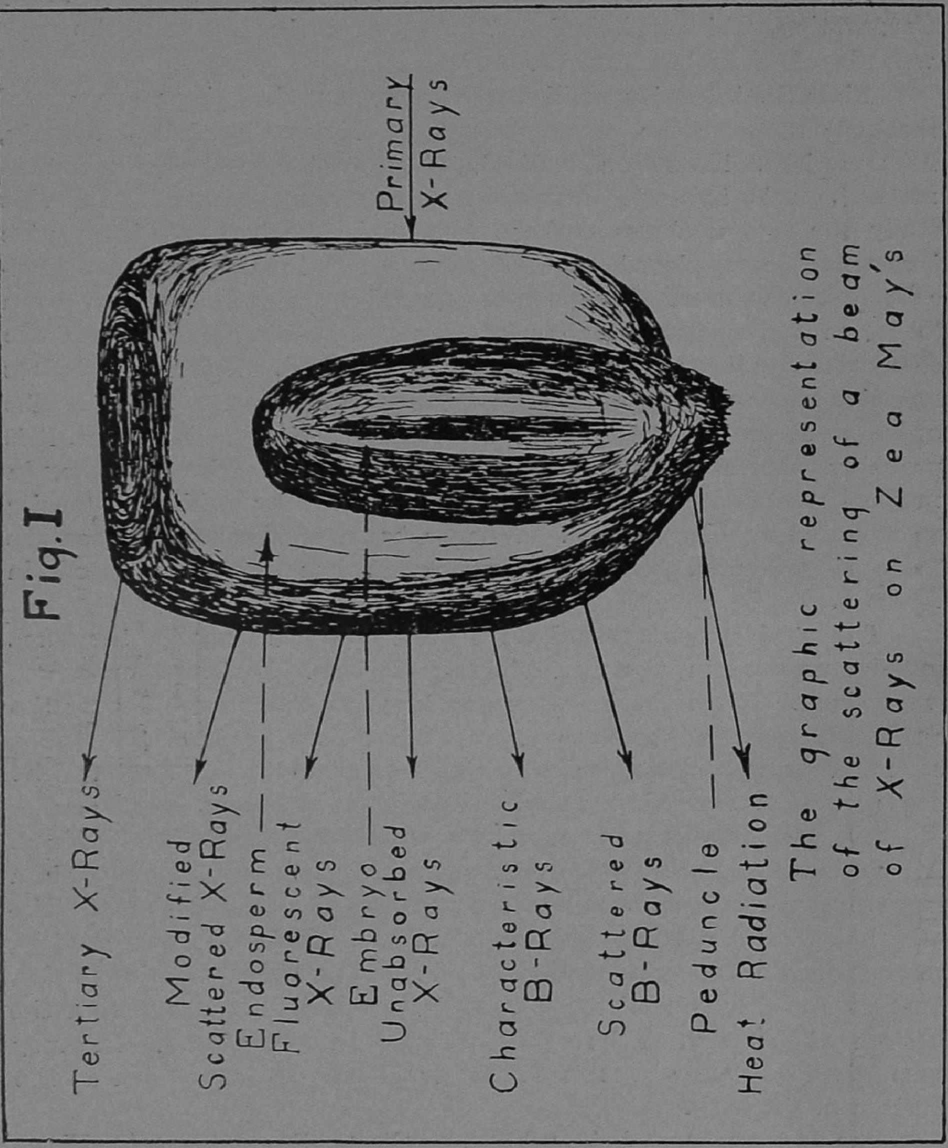


Fig. I

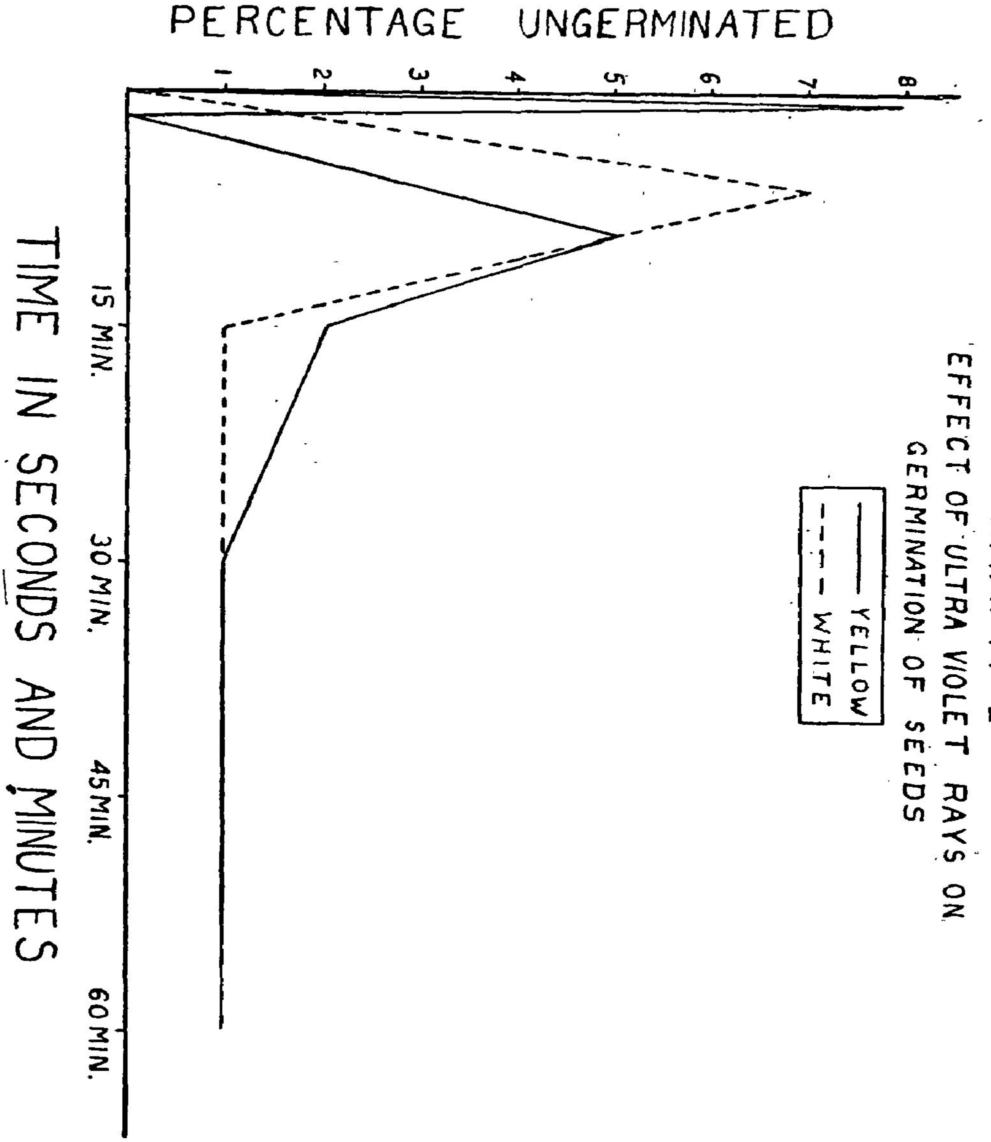
The graphic representation of the scattering of a beam of X-Rays on Zea May's

seeds were recorded daily. Few of them were transferred to other dishes for the qualitative observation of seedlings and their growth characteristics.

Discussion of Data.

(*a*) *Effect of ultra-violet radiation on seeds.*

The figures presented in Table I show the effect of various dosages of ultra-violet rays (dry seeds) on Zea Mays germination, (both as to rate and in character). It may be noted, that in the yellow



variety, all exposures with the exception of 30 seconds, and 10 minutes, the rays either did not influence at all or stimulated. At least the rays seem to have hastened the germination on

the fourth day. A dose of 10 seconds was decidedly stimulative, as all the seeds germinated at that exposure. With 30 seconds and 10-minute exposures, 8 and 5 per cent respectively did not germinate. The data do not show any regularity. Control seeds germinated somewhat slower. No particular difference was noticed in germination of seeds exposed to the middle rays of the Ultra-violet region and the straight arch. If there was any difference, it was too small to be of any particular significance.

As to the character of growth, seeds with 10 seconds' exposure made very luxuriant growth. Those exposed for 30 seconds came next, while 5-minute exposure, caused less growth. All seedlings exposed up to 30 minutes, appeared alike. One hour's radiation seemed to have injured the seeds somewhat, because, although germinated, they made poor growth at first but recovered afterwards. By way of comparison, seedlings of the seeds exposed to straight arch for 5 minutes as well as from the untreated seeds, showed weaker growth.

The white variety showed a difference from the yellow ones. On the whole, the former showed lower percentage of germination on the fourth day, greater percentage on the fifth day, while the greatest percentage of yellow seeds germinated on the fourth day. Straight arch and 30-second exposures, gave the maximum results. At this exposure (30 seconds) there is a difference in the behavior of the two varieties, namely, that the maximum percentage remained ungerminated in yellow but all whites germinated. This may be attributed, at least in part, to the different colors of the seeds. The absorption coefficient of the two colors may be different.

With reference to growth, the general tendency of the seedlings was practically the same in both varieties, namely, that seeds exposed for 10 and 30 seconds made the best growth. However, in the yellow variety, the first place may be assigned to seeds from 10 minutes' radiation. In the white, the same place may be given for 30 minutes' exposure. Seeds exposed to straight arch produced rather unhealthy plants. Untreated seeds were also comparatively weaker. All other seedlings were alike. For the characteristic growth, made by individual groups, the last column of Table I may be referred to. Graph I shows the percentage of germination, at the end of 6 days.

(*b*) *The effect of X-rays on the seeds.*

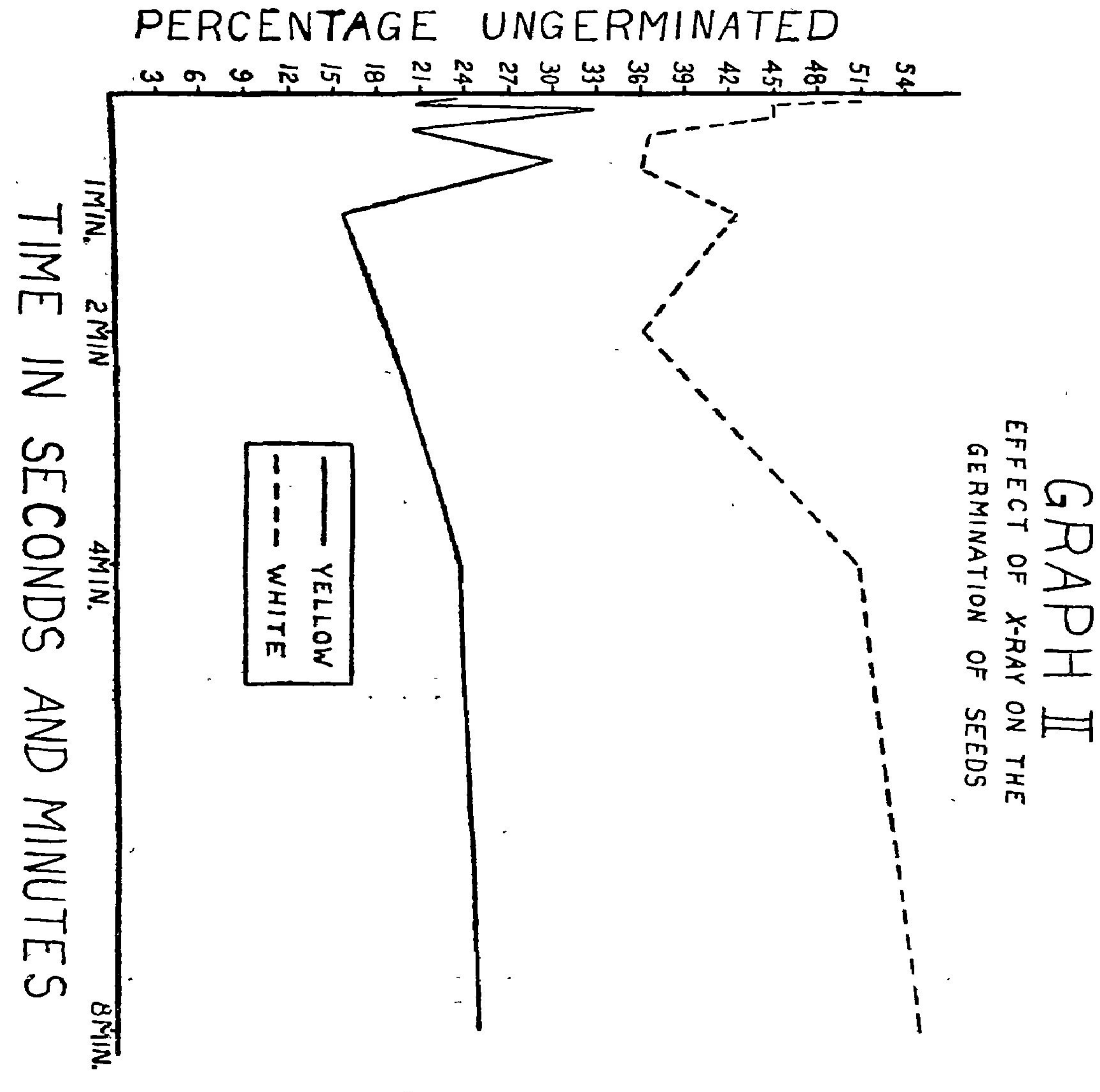
Table II shows the effect of X-rays on the air dry seeds, as measured by their germinating capacity. In the yellow variety, in general, the maximum percentage of exposed seeds germinated on the

Table I—Effect of Ultra-Violet Radiation on the Germination of Zea Mays.

Time of exposure.	Percentage of germination after. 4 days.	5 days.	6 days.	Percentage of ungerminated seeds.	Character of Growth and Remarks.
(Yellow variety)					
10 seconds ...	100	...	...	...	Very luxuriant Growth.
30 " ...	92	...	...	8	Appearance of seedling good.
1 minute ...	100	...	...	...	
5 minutes ...	97	3	...	...	Less Growth.
10 " ...	94	1	...	5	
15 " ...	98	...	...	2	Seedlings appeared similar.
30 " ...	98	1	...	1	
1 hour ...	97	2	...	1	Appeared bad at first but recovered soon.
Straight Arch					
5 minutes ...	98	1	...	1	Weaker seedlings and after growth.
Untreated (Control).	92	7	...	1	Weaker seedlings.
(White variety)					
10 seconds ...	72	27	...	1	Growth luxuriant.
30 " ...	89	11	...	...	Appeared to be best seedlings.
1 minute ...	94	5	...	1	Do. do.
5 minutes ...	58	3	...	7	
10 " ...	85	10	...	5	
15 " ...	82	17	...	1	Seedlings appeared very similar in growth.
30 " ...	92	7	...	1	
1 hour ...	83	16	...	1	
Straight Arch					
5 minutes ...	90	10	...	...	Appeared unhealthy but soon recovered.
Untreated (Control).	78	20	...	2	Weaker Growth.

NOTE 1.—Maximum temperature during exposure never exceeded 36°C.
" 2.—Fan was constantly blown to keep air in circulation without affecting the source of light.
" 3.—In calculations, less than 0.5 is ignored, while more than 0.5 is taken as 1.0.

third day ; while in the white variety, the minimum number germinated on the third day. In both varieties, 8-minute exposure brought about depressing effects. Both yellow and white varieties showed harmful influence exerted by X-rays. In the main, the percentage of



germinated seeds was low. On comparing the two varieties studied, the data seem to show that the white variety was more affected than the yellow one, because there was higher percentage of ungerminated seeds of the white variety than of the yellow. At the highest exposure of 8 minutes, both had the same percentage of total germination (100-55-45).

Table II—Effect of X-rays on the Germination of Zēa Mays.

Time of Exposure	Percentage of germination after.						Percentage of ungerminated seeds.	Character of Growth and Remarks.
	3 days	4 days	5 days	6 days	7 days	8 days		
(Yellow variety)								
1 second ...	60	15	1	...	1	...	23	Grew faster than below.
2 seconds ...	54	20	3	1	...	1	21	Seeds with less exposure made better and faster growth than with long exposures.
5 „ ...	50	16	...	...	...	1	33	
15 „ ...	40	37	2	...	...	1	20	
30 „ ...	29	35	5	...	...	1	30	
1 minute ...	40	41	13	...	...	...	26	
2 minutes ...	38	35	6	1	...	...	19	
4 „ ...	35	29	11	...	2	...	23	
8 „ ...	43	2	...	...	...	...	55	Some tips burnt.
Untreated (Control) ...	41	34	8	...	...	...	17	Growth very slow.
(White variety)								
1 second ...	4	29	14	2	...	...	51	Moulded and grew slow.
2 seconds ...	5	39	5	2	3	1	45	Some oozed their water.
5 „ ...	2	31	6	15	1	...	45	All appeared to be about the same speed of growth.
15 „ ...	1	34	21	5	...	2	37	
30 „ ...	12	43	5	4	...	...	36	
1 minute ...	12	22	22	1	...	...	43	
2 minutes ...	12	24	25	3	...	...	36	Made fast growth.
4 „ ...	12	10	26	1	...	...	51	
8 „ ...	5	10	26	4	...	...	55	
Untreated (Control) ...	39	21	7	...	...	...	33	Grew fastest.

Why did these two varieties show the different percentages of final germination except at exposure of 8 minutes? There seem to be three possibilities. (1) There may be genetic differences between the seeds not only in color but also in the protoplasm, structure or some such undetermined factor. This unknown factor may cause yellow variety of seeds more resistant in their capacity to endure the effect of X-rays than the white variety. (2) The two varieties may absorb different quality and quantity of X-rays because of their difference in color. Consequently one may be more effected than the other by X-ray treatment. (3) The two combined factors, namely, difference in color and the internal constitution (if any) between the two varieties, may together bring about different enduring powers in the two varieties. No data seem to be available at present in which such factors have been segregated.

Better seedlings were observed from yellow seeds under one second exposure, while the best growth was made by seedlings of white variety at 2-minute exposure. Even then, the growth was weaker than similar seeds exposed to ultra-violet rays. Whereas untreated white seeds grew fastest, similar yellow seeds made slow growth. There was decided injury to seedlings on longer exposures. And the symptoms of injury have been noted in the last column of table II. Graph II illustrates the percentage of ungerminated seeds under various dosages of X-rays for both varieties of seeds used. The maximum and minimum points as well as the general trend of the curve, seem to be alike in both varieties, although they are not identical.

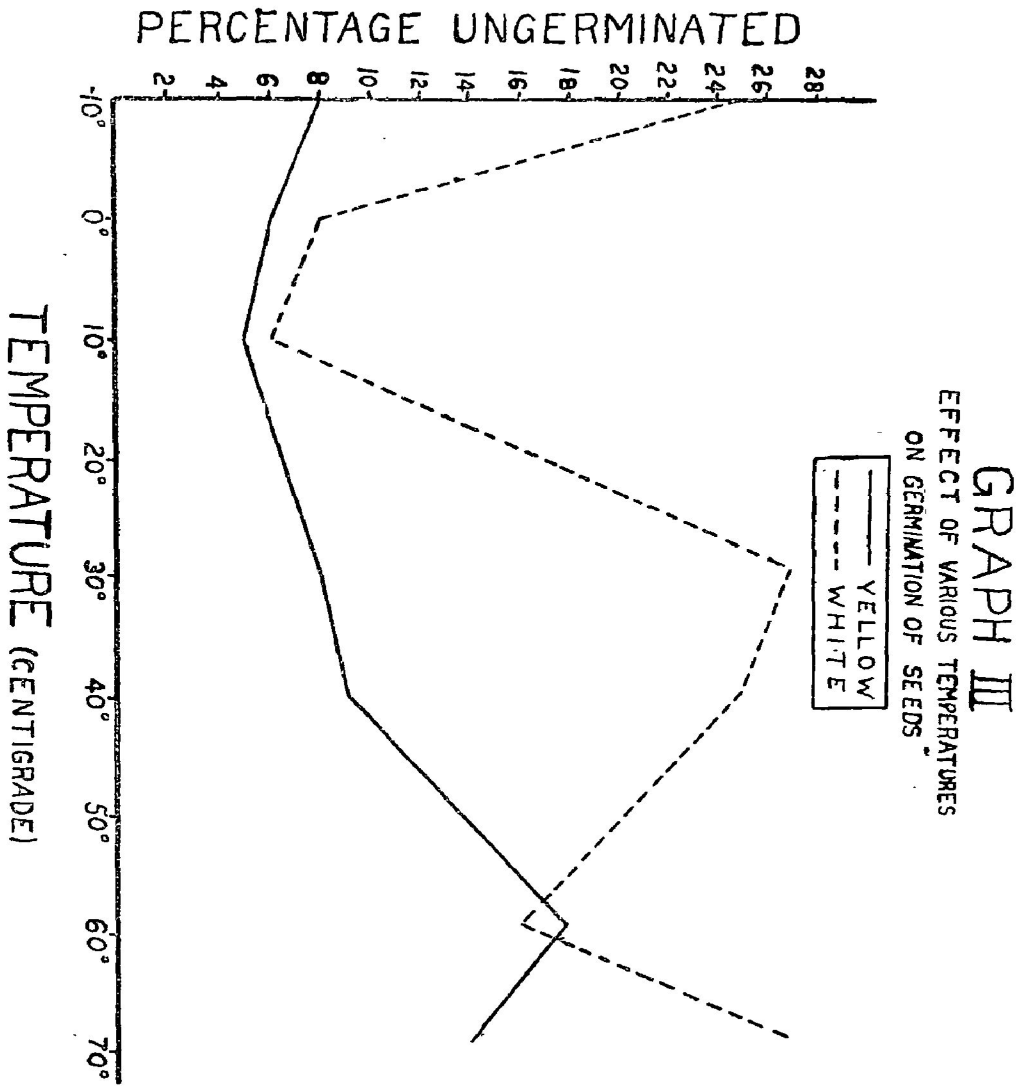
(c) *Effect of temperature on seeds.*

The data shown in table III point out the effect of temperature on seeds as indicated by their germinating power. In general, it would seem that maximum percentage of both varieties germinated on the third day. On the second day, comparatively smaller percentage of yellow seeds germinated but a greater number of white variety germinated. The percentage was just the opposite on the fourth day to that of the second day, as noted before. More seedlings of white than yellow corn appeared on the fifth day.

On the whole, temperatures from $-10°$C. to $40°$C. was found beneficial for the yellow variety of seeds. On the other hand, the range of $0°$ to $10°$C. seemed favorable for white seeds. Temperatures of $60°$C and $70°$C. were decidedly injurious to both varieties. However, seeds of white variety were more adversely affected than yellow. Temperature of $80°$C. proved to be fatal to all seeds.

As to the growth, seedlings of yellow variety made the best growth from seeds exposed to $-10°$ to $+10°$C. Similar growth was

shown by white variety at 0° and + 10°C., when compared with normal growth. As to the percentage of germination as well as the growth of the seedlings, it would seem that, in general, temperature from 0° to 10°C. yielded the best results during the course of these



experiments. Growth made by individual groups of seedlings may be ascertained by referring to the last column of table III.

The percentage of ungerminated seeds, due to temperature, for both varieties of seeds used have been illustrated by graph III.

Table III—Effect of Various Temperatures on the Germination of Zea Mays.

Temperature in C.	Percentage of germination after.				Percentage of ungerminated seeds.	Character of Germination and Remarks.
	2 days.	3 days.	4 days.	5 days.		
(Yellow variety)						
−10° ...	4	49	39	...	8	Seedlings made good growth.
0° ...	1	71	21	1	6	Seedlings made best growth.
10° ...	...	67	25	3	5	Do. do.
30° ...	...	56	35	1	8	
40° ...	...	56	34	1	9	
60° ...	8	48	26	...	18	
70° ...	5	41	36	4	14	In some seedlings tips burnt.
80° ...	...	...	...	...	100	All seeds died. Blue mould developed.
(White variety)						
−10° ...	22	30	11	12	25	Average growth.
0° ...	39	37	12	4	8	Good growth.
10° ...	16	56	18	4	6	Seedlings made the best growth.
30° ...	29	25	15	7	27	Normal growth as at room temperature (22°C.)
40° ...	28	31	9	2	25	
60° ...	37	34	11	2	16	
70° ...	24	34	15	...	27	In some seedlings, root tips burnt.
80° ...	...	...	...	...	100	All seeds died. Blue mould developed.

NOTE.—In calculations, less than 0.5 was neglected; while more than 0.5, was counted as 1.0.

Summary.

1. The effect of ultra-violet rays, X-rays and temperature on dry corn seeds, has been studied by means of the qualitative and quantitative germination tests.

2. The data seem to indicate that in general :—

(*a*) Slight exposures of ultra-violet rays show somewhat stimulative influence, both on the percentage of final germination as well as on the type of growth as displayed by the seedlings. The results, however, did not show any uniformity. The white and yellow varieties, responded differently at various exposures.

(*b*) X-rays show harmful effect. The white variety seem to be influenced more than the yellow by these rays. Types of injuries caused by X-rays are described.

(*c*) Comparison between the growth made by corn seedlings under ultra-violet rays and X-rays, has been made.

(*d*) Temperature of 60° and 70°C. appeared to be decidedly injurious. All seeds at 80°C. were absolutely killed. The seeds kept at 0 to 10°C. yielded better results in germination, both as to quality and quantity.

(*e*) All the results described in this paper are based on experimental work carried with Golden Bantan (yellow) and Shawnee (white) varieties of corn, commonly grown in the middle western states of the United States of America.

Acknowledgement.

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Mention must be made to acknowledge the splendid co-operation of Mr. Ray Glynn, Assistant, Biology Department, St. Mary's College.

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PLANTS FROM BASRA IN MESOPOTAMIA

Collected by H. WHITEHEAD, B.Sc.
(*Late Corporal, R. A. M. C.*) 1916–1918

BY

E. BLATTER, S.J., PH.D., F.L.S.

At last I have been able to name the small, but interesting collection sent to me by Mr. H. Whitehead in 1918.

Mesopotamia has been visited by many botanists. André Michaux was in Mesopotamia in 1782. Olivier and Bruguière, in 1795, crossed Syria and Mesopotamia on their way to Persia. For the same purpose Aucher Eloy was in Bagdad and other places in 1835. Col. Chesney, whilst exploring the lower course of the Euphrates in 1836, made a small collection of plants. In 1842 Kotschy gathered many specimens between Aleppo and Mosul. Noë, a physician of Trieste, who was attached to a Commission to fix the boundaries between Turkey and Persia, stayed at Bagdad and Babylon for a considerable time in 1851. In his spare time he examined the vegetation of the surrounding country. Mesopotamia was finally (in 1865) explored by Haussknecht. The materials brought together by these travellers were utilised by Boissier in his monumental Flora Orientalis. In more recent times we owe a good deal of information to Ascherson and Oppenheim, Bornmüller, Stapf, and especially to Handel-Mazzetti. The latter accompanied the Mesopotamia Expedition of the " Naturwissenchaftlichen Orientvereins in Vienna " in autumn 1910. The botanical results were published by him under the title : " Pteridophyta und Anthophyta aus Mesopotamien und Kurdistan sowie Syrien und Prinkipo " in the " Annalen des k. k. Naturhistorischen Hofmuseums," Wien (1912–1914). The same author described in 1914 " Die Vegetationsverhältnisse von Mesopotamien und Kurdistan."

Considering all that has already been done it might appear superfluous to publish a list of Basra plants. But a perusal of the existing botanical literature will show at once that Basra is perhaps the least known part of Mesopotamia. Even Handel-Mazzetti was not allowed to make a longer stay at Basra than of 10 days (1st–10th Oct.). It is natural that his references to this place are not very numerous. I have borrowed about half a dozen Basra plants from his list.

A Few Preliminary Notes.

The plants collected by Whitehead were all from the neighbourhood of Basra, and most of them were found growing on the banks of the irrigation creeks or in the adjoining plantations of Date Palms, and therefore on cultivated and irrigated land. A few exceptions to this being the desert plants from Jebel Sinam for which he was indebted to some of the Officers of the 33rd British General Hospital.

Under the localities "Makina Masus", which means "Liquorice Factory", will be mentioned repeatedly. The 33rd British General Hospital was stationed at this factory, but the name Makina Masus is now applied to the surrounding district.

CLIMATE.

(1) Temperature.

Official figures published in the "Basra Times" of 12 years' records for the months of June to November are as follows :—

	June	July	Aug.	Sept.	Oct.	Nov.
Mean Max. (Shade)	99.7	103.3	104.2	99.5	89.1	75.3
Highest Max. ,,	116.9	114.4	120.5	112.3	105.3	92.4
Mean Min. ,,	80.8	81.8	81.0	74.9	66.4	57.0
Lowest ,,	70.3	65.7	68.7	61.9	49.5	49.6

The records for the remaining months were not published, but during the winter the mercury falls to freezing point as thin pellicles of ice were seen on puddles in early morning.

The soil temperature rises during the summer to as high as 130° as an experiment with a thermometer showed. The experiment was made in the immediate neighbourhood of living plants of *Capparis galeata* and *Alhagi camelorum*.

(2) Rainfall.

An improvised, but fairly accurate, rain gauge was used during the rainy season (December to March) of 1917–1918 and registered a total fall of 8.45 inches. Practically no rain falls during the remainder of the year, though the dew-point is high during S.E-ly winds up the Persian Gulf.

SOIL.

With the exception of the plants from Jebel Sinam, all specimens were found growing on alluvial soil. This is a marly clay, rich in calcium carbonate. Strong hydrochloric acid produced a brisk effervescence when dropped on the soil and this applied to samples taken from several parts of the neighbourhood. An average sample was

taken, dried, weighed and treated with HCl. The residue was washed, dried and weighed and it was found that there was a loss of 43.5 % in weight due chiefly to the extraction of carbonates of calcium, magnesium, etc.

PLANT ASSOCIATIONS, Etc.

(1) Aquatic plants (Leaves submerged or floating).

Ranunculus aquatilis
Limnanthemum nymphoides
Ceratophyllum demersum
Potamogeton sp.
Zannichellia palustris

(2) Ditches. A. Partly or wholly submerged by the tides.

Ranunculus sceleratus
Eclipta erecta
Veronica anagallis
Polygonum glabrum
Rumex dentatus
Euphorbia sp.

B. Tops of banks above tide level.

Fumaria parviflora
Spergula pentandra
Geranium dissectum
Coronilla scorpioides
Malva parviflora
M. nicaeensis
Corchorus trilocularis
Pulicaria sp.
Sonchus oleraceus
Xanthium strumarium
Anagallis arvensis
Solanum nigrum
Verbena officinalis
Lippia nodiflora
Alternanthera sessilis
Chenopodium album
Polygonum sp.
Rumex obtusifolius
Euphorbia sp.
Chrozophora hierosolymitana
Phyllanthus maderaspatensis

(3) Shade plants (Undergrowth in Palm plantations).

Eruca sativa
Fumaria sp.
Malva parviflora
M. nicaeensis
Corchorus trilocularis
Geranium dissectum
Lathyrus aphaca
Vicia peregrina
Melilotus indicus
Glycyrrhiza glabra, v. *glandulifera*
Trifolium pratense
Caucalis daucoides
Galium apparinoides
Pulicaria sp.
Anagallis arvensis
Chenopodium album
Cyperus sp.

(4) River banks (Unshaded).

Ranunculus asiaticus
Hibiscus cannabinus
Morus indica
M. alba

Malva parviflora
M. nicaeensis
Trifolium pratense
Lotus ? angustissimus
Cordia Myxa
Moniera cuneifolia
Phyllanthus maderaspatensis
Salix acmophylla
Cyperus sp.
C. sp.
Chloris virgata

(5) Exposed places (Roadsides, and unshaded ground, railway banks, etc.).

Capparis galeata
Tamarix aphylla
Alhagi maurorum
Prosopis Stephaniana
Acacia Farnesiana
Scorpiurus sulcata
Aizoon hispanicum
Lycium barbarum
Chloris virgata

(6) Weeds in cornfields, etc.

Malcolmia sp.
Saponaria vaccaria
Spergula arvensis
Geranium dissectum
Erodium cicutarium
Trifolium sp.
Lathyrus sp.
Heliotropium Eichwaldii
Nepeta sp.
Urtica dioica
Andropogon sp.
Panicum sp.
Setaria verticillata

(7) Sandy desert (Plants from Jebel Sinam).

Silene sp.
Libanotis sp.
Matricaria chamomilla
Gnaphalium luteo-album
Cousinia sp.
Koelpinia linearis
Pulicaria sp.
Arnebia hispidissima
A. cornuta
Scrophularia sp.
Pteropyrum Olivieri
Calligonum polygonoides.

DICOTYLEDONEAE

RANUNCULACEAE

Ranunculus sceleratus Linn Sp. Pl. (1753) 551; Boiss. Fl. Or. I (1867) 52.—(No. 27). Grows below high water level in ditches; flowers project above high water.—*Flrs* Feb.-April.—Plants die down in May, but leaves reappear in January.

Distr.: Persia, Syria, Palestine, Arabia, Petraea, N. Africa, Europe, N. India, N. America.

Ranunculus aquatilis Linn. Sp. Pl. (1753) 556 (*partim*).—(No. 29). Fairly common.—*Flrs.* March and April.

Distr.: Temperate regions of the northern hemisphere.

Ranunculus asiaticus Linn. Sp. Pl. (1753) 552 ; Boiss. Fl. Or. I (1867) 31.—(No. 113). Banks of Euphrates near the junction with the Tigris.—*Flrs.* April.

Distr.: Mediterranean to Persia.

PAPAVERACEAE

Papaver somniferum Linn. Sp. Pl. (1753) 508 ; Boiss. Fl. Or. I (1867) 16.—(No. 140). Probably a garden escape.—*Flrs.* March.

Distr.: Generally cultivated in the warm and temperate regions of Europe, Asia, and N. Africa.

FUMARIACEAE

Fumaria densiflora DC. Cat. Pl. Hort. Monsp. (1813) 113.—*F. micrantha* Lag. Gen. and Sp. Nov. (1816) 21 ; Boiss. Fl. Or. I (1867) 136.—(No. 82). Makina Masus.—*Flrs.* March.

Distr.: Mediterranean region, S. Europe, Arabia, Persia, India.

Fumaria parviflora Lam. Encycl. II (1786) 567 ; Boiss. Fl. Or. I (1867) 135.—*F. Vaillantii* Aschers. in Rohlfs Kufra 409 *et* 508 (*non* Lois.).—(No. 33). Common, Makina Masus.—*Flrs.* March and April.

Distr.: Temperate regions of the Old World.

CRUCIFERAE

Malcolmia torulosa (Desf.) Boiss. Fl. Or. I (1867) 225, **var. contortuplicata** Boiss. l c.—(No. 50). Weed in cornfield, Makina Masus.—*Flrs.* April.

Distr. : Mediterranean region, W. Asia, Persia, Punjab.

Eruca sativa Lam. Fl. Franc. II (1778) 496 ; Boiss. Fl. Or. I (1867) 396.—(No. 68). Under palm trees, common throughout the district.—*Flrs.* January to March.

Distr. :—Mediterranean region, Middle Europe, Persia, India.

Note: There are several other specimens of *Cruciferae*, but for want of fruits it is impossible to name them :

(No. 78). Corolla pinkish purple.—Makina Masus.—*Flrs.* March.

(No. 79 and 79a). Corolla pale yellow.—Makina Masus.—*Flrs.* March.

(No. 80). Flowers undeveloped.—Makina Masus —*Flrs.* March.

(No. 84). Very much like *Lepidium draba.*—Banks of Kandaq Creek.—*Flrs.* March.

(No. 149). Corolla white.—Makina Masus.—*Flrs.* May.

CAPPARIDACEAE

Capparis Sicula Duham. Traité des arbres et fruitiers, nouv. ed. I (1808) 159.—C. *spinosa* var. *canescens* Boiss. Fl. Or. I (1867) 420.—Basra (ex Handel-Mazzetti).

Distr.: Greece, Crete, Macedonia, Armenia, Caucasus, Syria, Persia.

Capparis galeata Fres. in Mus. Senck. II (1837) 111; Boiss. Fl. Or. I (1867) 421.—*C. spinosa* Linn. var. *galeata* Hook. *f. et* Th. in Fl. Brit. Ind. I, pt. 1 (1872) 173.—(No. 5). Common throughout the district.—"Commences to throw out shoots in April, and flowers from May to October. The fruits are rarely seen before September, and at first are inconspicuous. As soon as dehiscence has taken place the bright crimson colour of the pulp immediately attracts attention. The pulp is sweet and is probably eaten by some bird or mammal as it soon disappears and the seeds also. I have sought many times for seeds beneath fruits the pulp of which has been eaten but never with success." (Whitehead).

CARYOPHYLLACEAE

Spergula arvensis Linn. Sp. Pl. (1753) 440.—(No. 51). In cornfield, Makina Masus.—*Flrs.* April.

Distr.: A weed of cultivation in all temperate regions.

Spergula flaccida Aschers. in Verhandl. Bot. Ver. Prov. Brandbg. XXX (1889) p. XXXIV-XLIX.—*Arenaria flaccida* Roxb. Fl. Ind. II (1832) 447.—*Spergula pentandra* var. *intermedia* Boiss. Diag. Pl. Or. ser. 2, fasc. 1, 93.—(No. 69). Banks of Robat Creek.—*Flrs.* March.

Distr.: Of the preceding species.

Silene sp. (No. 105). Corolla white with pink veins beneath.—Sandy desert, Jebel Sinam.—*Flrs.* April.

Saponaria Vaccaria Linn. Sp. Pl. (1753) 409.—(No. 135). Garden, Makina Masus.—*Flrs.* April.

TAMARICACEAE

Tamarix aphylla Lanza in Bull. Orto Bot. Palermo VIII (1909) 82.—*Thuya aphylla* Linn. Cent. Pl. I, 32.—*T. articulata* Vahl. Symp. II (1791) 48, t. 32.—(No. 8). Dry places, Tanoona.—*Flrs.* June.—(No. 58). Grows in patches in sandy desert near Fort Shaiba. *Flrs.*—January.

Distr.: Mediterranean region, Arabia, Persia, Baluchistan, Sind.

Tamarix passerinoides Del. Ill. Flor. d'Eg. (1813) 352; Boiss. Fl. Or. I, 778.—*T. pycnocarpa* DC. Prodr. I, 97.—*Trichaurus Aucherianus* Decsne. in Jacq. Voy. 59.—(No. 65). Near Gurmat Ali.—*Flrs.* February.

Distr.: Egypt, Transcaucasus, Persia, Afghanistan.

MALVACEAE

Malva parviflora Linn. Amoen. Acad. III, 416; Boiss. Fl. Or. I (1867) 820.—(No. 97). Makina Masus.—*Flrs.* April.

Distr.: Mediterranean region, Nubia, Arabia, Persia, Afghanistan, N.-W. India, Sind.

Malva nicaeensis All. Pedem. II, 40; Boiss. Fl. Or. I (1867) 819.—(No. 98). Makina Masus.—*Flrs.* April.

Distr.: Mediterranean region to Persia.

Malva rotundifolia Linn. Sp. Pl. (1753) 688 (*partim*); Boiss. Fl. Or. I (1867) 820.—(No. 151).

Distr.: Europe, N. Africa, N. and W. Asia to India.

Abutilon indicum Sw. Hort. Brit. ed. 1 (1827) 54.—(No. 156), Khandaq Creek.—*Flrs.* May.

Distr.: Spread throughout the tropical zone in both hemispheres.

Abutilon glaucum Sw. Hort. Brit. ed. 1. (1827) 54.—*A. muticum* Webb. Frag. Fl. Aethiop. (1835) 51.—(No. 151). Makina Masus.—*Flrs.* May to August.

Distr.: Mediterranean region, tropical Africa, Cape, Arabia, Afghanistan, India, Ceylon, Australia.

Hibiscus cannabinus Linn. Syst. ed. X (1759) 1149.—(No. 71). Robat Creek.—*Flrs.* March.

Distr.: Cultivated in most tropical countries.

Hibiscus trionum Linn. Sp. Pl. (1753) 697; Boiss. Fl. Or. I (1867) 840.—(No. 146). Makina Masus.—*Flrs.* May.

Distr.: Common throughout Africa and S. Asia, extending northwards to China and the Amur.

Hibiscus esculentus Linn. Sp. Pl. (1753) 696.—Grown in gardens as a vegetable.

Distr.: Naturalized in all tropical countries.

TILIACEAE

Corchorus trilocularis Linn. Mant. (1764) 77.—(No. 22). Common throughout the district.—*Flrs.* March to January.

Distr.: Tropical and S. Africa, Arabia, Afghanistan, India,

LINACEAE

Linum usitatissimum Linn. Sp. Pl. (1753) 277.—(No. 134). Garden, Makina Masus, also banks of ditches.

Distr.: Extensively cultivated.

GERANIACEAE

Geranium dissectum Linn. Sp. Pl. (1753) 956.—(No. 43). Common throughout the district.—Leaves appear in January.—*Flrs.* March and April.

Distr.: Middle Europe, Mediterranean, Caucasus, Mesopotamia, Persia.

Erodium cicutarium (Linn.) L'Hér. Géraniol. (1787) 5, n. 12; Boiss. Fl. Or. I (1867) 890.—(No. 93). Ditches in the open, Nahr Umar. In garden, Makina Masus.—*Flrs.* March to May.

Distr.: Mediterranean region, Europe, Arabia, Mesopotamia, Persia, Afghanistan, Baluchistan.

RHAMNACEAE

Zizyphus Spina Christi Willd. Sp. Pl. I (1797) 1105.—Basra, cultivated (ex Handel-Mazzetti).

Distr.: Mediterranean, tropical Africa, Arabia, Persia, Afghanistan.

Zizyphus Spina Christi Willd. var. **inermis** Boiss. Fl. Or. II (1872) 13.—(No. 81). Near old Turkish Forts.

LEGUMINOSAE

Coronilla scorpioides (Linn.) Koch Syn. Fl. Germ. ed. I (1835) 188; Boiss. Fl. Or. II. (1872) 183.—(No. 123). Fairly common.—*Flrs.* April. Young plants appear in January.

Distr.: Mediterranean region, Mesopotamia, Transcaucasus, Persia.

Lotus ? angustissimus Linn. Sp. Pl. (1753) 1090.—(No. 95). River bank, Gurmat Ali.—*Flrs.* March.

Distr.: Mediterranean region and Orient.

Medicago sativa Linn. Sp. Pl. (1753) 778; Boiss. Fl. Or. II (1872) 94.—(No. 144). Grown for fodder. With careful irrigation four crops can be obtained per year.

Distr.: Country of origin unknown. Cultivated everywhere.

Trifolium lappaceum Linn. Sp. Pl. (1753) 1082.—(No. 140). Bank of creek, Makina Masus.—*Flrs.* May.

Distr.: Canaries, Mediterranean, N. Africa, Orient.

Trifolium pratense Linn. Sp. Pl. (1753) 1082.—(No. 140). Banks of Euphrates.—*Flrs.* April.

Distr.: Europe, Orient, Siberia.

Trifolium sp.—(No. 52). Weed in cornfield, Makina Masus. —*Flrs.* April.

Vicia peregrina Linn. Sp. Pl. (1753) 737; Boiss. Fl. Or. II (1872) 576.—(No. 39). Ditches, Makina Masus.—*Flrs.* March-April.

Distr.: Europe, Mediterranean region to Persia.

Lathyrus Aphaca Linn. Sp. Pl. (1753) 729; Boiss. Fl. Or. (1872) 602.—(No. 34). Common in shade of palm trees.—*Flrs.* March and April.—Seedlings appear early in January.

Distr.: Europe, Mediterranean region, Orient.

Lathyrus sativus Linn. Sp. Pl. (1753) 730; var. **stenophyllus** Boiss. Fl. Or. II (1872) 607.—(No. 94). Makina Masus.—*Flrs.* March.

Distr.: Europe, Mediterranean region, Abyssinia, Orient.

Lathyrus sp. (No. 143). Garden, Makina Masus.—Standard reddish purple on outside, and bluish purple inside.—*Flrs.* May.

Alhagi Maurorum Medic. in Vorles. Churpf. Phys. Ges. II (1787) 397; Boiss. Fl. Or. II (1872) 558.—(No. 1 and 53). Common.—Shoots commence to develop in April. Leaves fall off about the end of June.—*Flrs.* June to August.

Melilotus indicus Linn. Sp. Pl. (1762) 1077.—*M. parviflora* Desf. Fl. Atl. II (1798) 192; Boiss. Fl. Or. II (1872) 108.—(No. 35 and 157). Common.—*Flrs.* March and April.

Glycyrrhiza glabra Linn. Sp. Pl. (1753) 1048, var. **glandulifera** (Reg. & Herd.) Boiss. Fl. Or. II (1872) 202.—(No. 4). Growing in profusion near the Liquorice Factory, Makina Masus. Most of the liquorice root comes from near Bagdad.—*Flrs.* April to June.—Specimens in flower are not very common and are then found only in sunny situations. The leaves fall in November.

Distr.: Mediterranean region, Orient.

Trigonella Foenum graecum Linn. Sp. Pl. (1762) 1095; Boiss. Fl. Or. II (1872) 70.—(No. 77). Makina Masus.—*Flrs.* March.

Distr.: Mediterranean region, Arabia, Orient.

Sesbania aegyptiaca Pers. Syn. II (1807) 316; Boiss. Fl. Or. II (1872) 193.—(No. 175). Robat Creek.—*Flrs.* August to October. " The plant shows marked heliotropism. The plane of the leaflets is almost at right angles to the angle of incidence of the sun's rays and this is maintained throughout the day. The leaflets fold together soon after sunset." (Whitehead).

Distr.: Senegal, Nubia, Egypt, Orient, tropical Asia, N. Australia.

Scorpiurus sulcata Linn. Sp. Pl. (1753) 1050; Boiss. Fl. Or. II (1872) 179. (No. 125).—Fairly common.—*Flrs.* March.

Distr.: Mediterranean, Mesopotamia, Persia, Abyssinia.

Psoralia corylifolia Linn. Sp. Pl. (1753) 764.—*Trifolium unifolium* Forsk. Fl. Aegypt.—Arab. (1775) CXVIII, n. 460 and p. 140.—(No. 176). Ditches, Makina Masus.—*Flrs.* August to October.

Distr.: Arabia, India, Ceylon.

Acacia Farnesiana Willd. Sp. Pl. IV (1805) 1083.—(No. 25). Makina Masus, planted.—*Flrs.* April.

Distr.: Cosmopolitan in the tropics, often planted.

Prosopis Stephaniana Kunth in Spreng. Syst. II (1825) 326.—(No. 3). Common throughout the district.—*Flrs.* June. *Fruits* July.—Shoots appear at the beginning of April. Leaves fall about the end of December.

Distr.: Caucasus, Orient to Afghanistan and India.

FICOIDACEAE

Mollugo hirta Thunb. Prod. Pl. Cap. 24.—(No. 14). Damp places, Makina Masus.—*Flrs.* November.

Distr.: Tropical and subtropical regions.

Aizoon hispanicum Linn. Sp. Pl. (1753) 700; Boiss. Fl. Or. II (1872) 765.—(No. 75). Rain-puddle near Turkish Fort.—*Flrs.* March.

Distr.: Mediterranean region, Orient to Persia.

UMBELLIFERAE

Bupleurum sp.—(No. 66). In rainwater puddle, Makina Masus.—*Flrs.* March.

Seseli sp.—(No. 88). Robat Creek. Makina Masus.—*Flrs.* March.

Caucalis daucoides Linn. Sp. Pl. (1753) 346; Boiss. Fl. Or. II (1872) 1084.—(No. 101). Shady places, Makina Masus.—*Flrs.* April.

Pimpinella sp.—(No. 60).—*Flrs.* July; fruit not fully developed.

RUBIACEAE

Galium spurium Linn. Sp. Pl. (1753) 154; Boiss. Fl. Or. III (1875) 69.—*G. aparinoides* C. Koch in Linnaea XVII, 33.—(No. 70). Makina Masus.—*Flrs.* March.—Seedlings appear in December.

Distr.: Mediterranean region, Orient to Persia.

COMPOSITAE

Gnaphalium luteo-album Linn. Sp. Pl. (1753) 1196; Boiss. Fl. Or. III (1875) 224.—(No. 108). Jebel Sinam.—*Flrs.* April.

Distr.: Cosmopolitan, except in the Arctic regions.

Xanthium strumarium Linn. Sp. Pl. (1753) 987, var. **antiquorum** (Wallr.) Boiss. Fl. Or. III (1875) 252.—(No. 24).—*Flrs.* October.—" A duck shot on the river Euphrates on Dec. 22nd, 1917 had five fruits of this species firmly embedded in the down feathers over the rump. The fruits could not be removed without tearing away feathers." (Whitehead).

Distr.: Widely distributed especially in the warmer regions of the N. hemisphere.

Matricaria Chamomilla Linn. Sp. Pl. (1753) 1256; Boiss. Fl. Or. III (1875) 323.—(No. 106). Jebel Sinam.—*Flrs.* April.

Distr.: Of Mediterranean origin.

Pulicaria sp.—(No. 9 and 16).—Common on sides of ditches. New shoots spring from stock in February.—*Flrs.* May to December.

Pulicaria sp.—(No. 116). Jebel Sinam.—*Flrs.* April.

Carduus sp.—(No. 150). Makina Masus.—*Flrs.* May.

Centaurea sp. *accedens ad C. calcitrapam* Linn.—(No. 168). Makina Masus.—*Flrs.* June.

Cousinia sp.—(No. 111). Jebel Sinam.—*Flrs.* April.

Sonchus oleraceus Linn. Sp. Pl. (1753) 1116.—(No. 49). Common in ditches.—*Flrs.* March to June.

Distr.: Cosmopolitan.

Eclipta erecta Linn. Mantiss. II (1771) 286.—(No. 13).—*Flrs.* All the year round.

Koelpinia linearis Pall. Itin. III App. (1776) 755; Boiss. Fl. Or. III (1875) 721.—(No. 115). Jebel Sinam.—*Flrs.* April.

Distr.: Mediterranean region, Orient to India.

Launaea sp.—(No. 164). Jebel Sinam.—*Flrs.* April. "Leaves vertical and with the leaf planes radiating from the stem." (Whitehead)

PLUMBAGINACEAE

Statice spicata Willd. Sp. Pl. I, 1533: Boiss. Fl. Or. IV (1879) 871.—(No. 131). Robat Creek, Makina Masus, only one specimen seen. —*Flrs.* April.

Distr.: Mediterranean, Orient to Baluchistan, Siberia.

PRIMULACEAE

Anagallis arvensis Linn. Sp. Pl. (1753) 148.—(No. 36). Very common. The form with blue flowers is the commoner, though the red occurs also.—*Flrs.* March to April. Withers in June.

Distr.: Cosmopolitan.

GENTIANACEAE

Limnanthemum nymphoides Link. Port. I, 344.—(No. 62). Ditch near Makina Masus.—*Flrs.* April.

BORAGINACEAE

Cordia Myxa Linn. Sp. Pl. (1753) 190; Boiss. Fl. Or. IV (1879) 124.—(No. 83). Robat Creek, cultivated. Not in flower.

Distr.: Tropical Africa, Madagascar, Egypt, Arabia, Tropical Asia, Queensland.

Arnebia hispidissima DC. Prodr. X (1846) 94; Boiss. Fl. Or. IV (1879) 213.—(No. 109). Jebel Sinam. Corolla yellow.—(No. 110). Corolla purple.—*Flrs.* April.

Distr.: Tropical Africa, Egypt, Arabia, Persia, India.

Arnebia cornuta F. & M. Ind. Petr. 1835; Boiss. Fl. Or. IV (1879) 213.—(No. 119). Jebel Sinam.—*Flrs.* April.

Distr.: Mediterranean region, Arabia, Mesopotamia, Persia, Siberia.

Heliotropium Eichwaldi DC. Prodr. X, 535; Boiss. Fl. Or. IV (1879) 131.—(No. 153). Garden, Makina Masus.—*Flrs.* May.

Distr.: Mediterranean region, Arabia, Persia, Afghanistan, Central Asia.

CONVOLVULACEAE

Cressa cretica Linn. Sp. Pl. (1753) 223; Boiss. Fl. Or. IV (1879) 114.—(No. 7 and 174). Dry places, common.—*Flrs.* June to August.

Distr.: Cosmopolitan.

Ipomoea sp.—(No. 12). Makina Masus.—*Flrs.* Nov.

Convolvulus arvensis Linn. Sp. Pl. (1753) 153; Boiss. Fl. Or. IV (1879) 108.—(No. 145). Common on creek banks.—*Flrs.* May to August.

Distr.: Tropical Africa, Arabia, temperate regions of both hemispheres.

SOLANACEAE

Solanum nigrum Linn. Sp. Pl. (1753) 136.—(No. 23). Common on sides of ditches; in date plantations (ex Handel-Mazzetti).—*Flrs.* Throughout the year.

Distr.: Almost cosmopolitan.

Lycium barbarum Linn. Sp. Pl. (1753) 192 (*partim*).—*L. europaeum* Linn. Sp. Pl. (1753) 192, probably.—(No. 64). Ditches by roadsides, near Makina Masus.—*Flrs.* January to March. Plant withers in July.

Distr.: Mediterranean region, Canaries, Mesopotamia, Persia, Afghanistan, Baluchistan, Punjab.

SCROPHULARIACEAE

Scrophularia sp.—(No. 118). Sandy desert, Jebel Sinam.—Calyx with thin membranous border. Upper lip of corolla deep purple, remainder purple.—*Flrs.* April.

Veronica anagallis Linn. Sp. Pl. (1753) 12.—(No. 26). In ditches and damp places, common.—*Flrs.* February to May.—Plant withered in June.

Distr.: Nearly all warm and temperate regions.

Linaria ramosissima Wall. Pl. As. Rar. II (1831) 43, t. 153, var. **cabulica** (Benth.) *nov. comb.*—*L. cabulica* Benth. in DC. Prodr. X (1846) 270.—(No. 55). Common under shade of palm trees.—*Flrs.* May to October.—Plant withered in November.

Distr.: S. Persia, Afghanistan, Sind.

Moniera cuneifolia Mich. Fl. Bor. Amer. II (1803) 22.—*Herpestis Monniera* H. B. & K. Nov. Gen. & Sp. Pl II (1817) 366.—(No. 67). Banks of Robat Creek.—*Flrs.* March.

Distr.: All warm countries.

VERBENACEAE

Lippia nodiflora Mich. Fl. Bor. Amer. II (1803) 15.—(No. 10 and 15). Common in damp places. In exposed situations the plant forms a carpet.—*Flrs.* April to November.—Leaves take on a reddish tint in December.

Distr.: Most tropical and subtropical regions.

Verbena officinalis Linn. Sp. Pl. (1753) 29.—(No. 17). Common on banks of ditches.—*Flrs.* April to August.—Leaves fall in December though a few radical leaves were noticed in January.

LABIATAE

Nepeta sp. (No. 152). Garden, Makina Masus.—*Flrs.* May.—Corolla pinkish purple.

PLANTAGINACEAE

Plantago lanceolata Linn. Sp. Pl. (1753) 164.—(No. 137). Banks of Creek, Makina Masus.—*Flrs.* June to November.

Distr.: Temperate regions of the whole world, tropical Africa.

AMARANTHACEAE

Amaranthus Blitum Linn. Sp. Pl. (1753) 990.—(No. 121). Bank of Creek, Makina Masus.—*Flrs.* November.

Distr.: In all warm countries, wild or cultivated.

Amaranthus gangeticus Linn. Syst. Nat. ed. 10 (1759) 1268.—(No. 160 and 169). Makina Masus.—*Flrs.* June.

Distr.: Tropics generally, cultivated or as an escape.

Alternanthera sessilis R. Br. Prodr. (1810) 417.—*A. triandra* Lam. Encyc. Méthod. I (1783) 95.—(No. 59). Ditches just above water line, Makina Masus.—*Flrs.* December–February.

Distr.: All warm countries.

CHENOPODIACEAE

Chenopodium album Linn. Sp. Pl. (1753) 219.—(No. 100, 126 and 148). Common in ditches and damp places.

Distr.: Cosmopolitan.

Suaeda fruticosa Forsk. Fl. Aegypt. Arab. (1775) 70, var. **brevifolia** Boiss. Fl. Or. IV (1879) 939.—(No. 173). Dry places.—*Flrs.* April.

Distr.: N. Africa and Europe, extending to England and through the Orient to India.

Spinacia tetrandra Stev. in Mem. Nat. Mosc. II. 182; Boiss. Fl. Or. IV (1837) 906.—(No. 99). Makina Masus.—*Flrs.* April.

Distr.: Orient to Afghanistan.

POLYGONACEAE

Polygonum glabrum Willd. Sp. Pl. II, 447. (No. 19). Common in ditches.—*Flrs.* October to December.

Distr.: Throughout the tropics.

Polygonum serrulatum Lag. Nov. Gen. & Sp. 14.—Basra, at the Khora Canal (ex Handel-Mazzetti)—*Flrs.* October.

Distr.: Mediterranean region, tropical and S. Africa, Orient to India.

Polygonum Persicaria Linn. Sp. Pl. (1753) 518.—Basra, at the Khora Canal (ex Handel-Mazzetti).—*Flrs.* October.

Distr.: Europe, Mediterranean, Orient to India, N. America.

Rumex dentatus Linn. Mant. (1762) 226, var. **pleiodon** Boiss. Fl. Or. IV (1879). 1013.—(No. 87). Ditch, Makina Masus.—*Flrs.* March.

Distr.: Mediterranean, Orient to Afghanistan and Baluchistan.

Rumex obtusifolius Linn. Sp. Pl. I. 578.—(No. 61). Ditches, Makina Masus.—*Flrs.* February and March.

Distr.: Europe, Mediterranean, Orient to Persia, Afghanistan and Baluchistan.

Pteropyrum Olivieri Jaub. and Sp. Ill. Pl. Or. II (1844) 9, t. 103.—(No. 107). Jebel Sinam.—*Flrs.* April.

Distr.: Persia, Afghanistan, Sind.

Calligonum polygonoides Linn. Sp. Pl. (1753) 530.—(No. 117). Jebel Sinam.—*Flrs.* April.

Distr.: Orient to Punjab, Sind, Rajputana.

EUPHORBIACEAE

Euphorbia Helioscopia Linn. ap. Wiman Diss. Euphorb. n. 42; Linn. Sp. Pl. (1753) 658.—(No. 48). Common.

Distr.: Mediterranean, Orient to Baluchistan.

Chrozophora hierosolymitana Spr. Syst. Veg. III (1826) 850.—(No. 11). Common on banks of creeks, etc.—*Flrs.* May to September.—Withers in November.

Distr.: Mediterranean, Orient to Afghanistan and Turkestan.

Note: Handel-Mazzetti mentions from Mesopotamia *C. verbascifolia* (Willd.) Juss. This species, according to Prain, includes *Croton verbascifolium* Willd. and, with this, three specimens collected by Aucher (2008, 5297 from Persia and 2006 from Syria) all of them belonging to C. *hierosolymitana* Spr. See D. Prain The Genus Chrozophora, in Kew Bull. (1918) 49.

Phyllanthus maderaspatensis Linn. Sp. Pl. (1753) 982.—(No. 18). Common.—*Flrs.* April to December.

Distr.: Tropical and extra-tropical regions of the Old World.

URTICACEAE

Urtica dioica Linn. Sp. Pl. 1396.—(No. 72). Garden, Makina Masus.—*Flrs.* March.

Distr.: Europe, N. Africa and N. Asia, Orient.

Morus alba Linn. Sp. Pl. (1753) 1398.—(No. 41). Common on river banks.—*Flrs.* March.—*Fruits* April.—A number of leaves fall in November.

Distr.: Cultivated in Europe, W. and Central Asia, the Orient and in China.

Morus indica Linn.—Cultivated, Robat Creek.—*Flrs.* April.

SALICACEAE

Salix acmophylla Boiss. Diagn. ser. 1, fasc. 7, 98.—(No. 30). Robat Creek.—*Flrs.* March.

Distr.: Orient.

Salix sp.—(No. 85). Common.—Spreading, 2-3 m. high—*Flrs.* March.

CERATOPHYLLACEAE

Ceratophyllum demersum Linn. Sp. Pl. (1753) 992.—(No. 45).

Distr.: Europe, Mediterranean region, Arabia, Asia.

MONOCOTYLEDONEAE

JUNCACEAE

Juncus sp.—(No. 147). Ditch, Makina Masus.—*Flrs.* May.

PALMAE

Phoenix dactylifera Linn. Sp. Pl. (1753) 1188.—Cultivated. —*Flrs.* Beginning of April. *Fruits* end of August and beginning of September.—"The Arabs assist in the pollination by collecting the

pollen in muslin bags, which they tie to the end of a stick. They then climb the female trees and by shaking the bag, dust the pollen over the pistillate flowers." (Whitehead).

NAIADACEAE

Zanichellia palustris Linn. Sp. Pl. (1753) 969, var. **pedicellata** Aschers. Fl. Brand. 669.—(No. 46). Ditches, Makina Masus.—*Flrs.* April.

Distr.: Cosmopolitan, except in Australia.

Potamogeton sp.—(No. 63). Ditches, Makina Masus, common. —*Flrs.* March.

CYPERACEAE

Cyperus sp.—(No. 172). Ditches, Makina Masus.—*Flrs.* July.

Carex sp.—(No. 161). Makina Masus.—*Flrs.* June.—(No. 92). Gurmat Ali.—*Flrs.* March.

GRAMINEAE

Chloris virgata Swartz Fl. Ind. Occ. I (1797) 203.—*C. meccana* Hochst. & Steud. Plant. Glum. I, 205.—(No. 2). Common.—*Flrs.* April to November.

Distr.: S. Africa, Egypt, Arabia, eastwards to Baluchistan.

Panicum sp.—(No. 6). Robat Creek.—*Flrs.* June.

Aeluropus villosus Trin. ex L. Mey. Verz. Pflanz. Cauc. (1831) 18.—(No. 57). Makina Masus; (No. 158). Dry places, fairly common. —*Flrs.* May to July.

Distr.: Mediterranean region, Arabia, Persia, Afghanistan, India, Ceylon.

Sorghum halepense Pers. Syn. I (1805) 101.—(No. 136). Ditches, Makina Masus.—*Flrs.* May.

Distr.: Most warm countries.

Andropogon sp.—(No. 142). Garden, Makina Masus.—*Flrs.* May.

Setaria verticillata Beauv. Agrost. (1812) 51.—(No. 166). Garden, Makina Masus.—*Flrs.* June.

Distr.: Temperate and tropical regions.

Echinochloa Crus Galli Beauv. Agrost. (1812).—Basra, on the Khora Canal (ex Handel-Mazzetti).

Distr.: Throughout the warm temperate countries of the N. hemisphere, rather rare in the tropics of Africa and the New World.

Saccharum Ravennae Linn. Syst. ed. XIII, 88.—*Erianthus Ravennae* Beauv. Agrost. 162.—Basra, on the Khora Canal (ex Handel-Mazzetti).

Distr.: From the Mediterranean to India.

CRYPTOGAMAE

SALVINIACEAE

Salvinia natans Willd. Sp. Pl. V, 536.—Occurs abundantly in some ditches. Sporocarps were never found.

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NOTES ON FOUR SPECIES OF FLOWERING PLANTS FROM THE SOUTH INDIAN HIGHLANDS

BY

P. F. FYSON

What appear to be species of Blumea and of Osbeckia hitherto unrecognised as distinct are described below, and also a new Notonia. A note is also added on Smilax zeylanica.

1. **Blumea hieracifolia.** The ordinary form, on the Nilgiri and Pulney hill-tops, of the species is scapigerous, the leaves forming a rosette at the base, the heads being in a compact corymb with yellow florets.

C. B. Clarke in his compositae-Indicae refers to them as his var. γ of a species, mainly developed in Bengal with yellow flowers.

Hooker in Flora of British India, Vol. III, p. 263 has a variety *macrostachya* which is much branched, and with heads in large clusters. Gamble in his Flora of the Madras Presidency has this variety as growing from the Northern Circars to the Pulneys and Tinnevelly Hills above 6,000 ft.

There is another form of Blumea, common on these hills, almost always with a simple leafy stem but occasionally branched. Possibly because the latter approaches in appearance branched forms of B. hieracifolia DC, this plant has been regarded as that species. There is, however, this difference, that the florets are purple not yellow, and less exserted. C. B. Clarke remarks indeed that the bracts of *B. hieracifolia* DC are occasionally purple, and this has probably been regarded as additional evidence in favour of our plant being that species. It appears to me, however, that the purple florets, unmistakable in fresh condition and discernible often in herbarium material, really differentiate the two, as well as the usually quite different habit (our plant never being scapigerous) and the shorter florets.

I therefore regard it as a different species, and as Gamble adopted the name 'macrostachya' as a "variety", for what I take to be this plant, I adopt it as the specific name—with however this caution, it may not be DeCandolle's *B. macrostachya*, for there seems to be some doubt as to what De Candolle, who originated the name, meant by it. C. B. Clarke did not know, but thought it might be *B. fasciata*, for he quotes *Wall. Cat.* 3002, 3094, 3064, 3055, none of which are quoted by Hooker in the F.B.I. for his var. *macrostachya*.

The plant under discussion is figured in my Flora of the Nilgiri and Pulney Hill tops t. 385, 384 and again in my Flora of the South Indian Hill Stations. t. 268. (Now in the press).

2. **Osbeckia rosea** *Fyson* (Melastomaciae–Osbeckieae) : ab O. sublaevis *Cogm.* ramulis nec succulentis, appendicibus longiores et foliis nec lineolatis : et ab O. octandra DC, pennicellato–setis sessilibus recedit. *Fructus* erectus ; ramuli quadrangulares, pilis erectis basi bulbatis instructi. *Folia* ovato-lanceolata, apice et basi acuta, 3.5 cm. longa, 1.5—2.5 cm. lata, supra virida subtus pallidora, supra pilis putertiam partem adpressis tecta, subtus at nervos copiosa instructa, e basi 5 nervia, nervis supra impressis : petiolio 2–9 mm. longi dense setis erectis hirsuti. *Inflorescentia* terminalis irregulare corymbo vel capito similis, pedicelei 2–3 mm. longi.

Reciptaculum penicellato-setis sessilibus at basem instructum supra ovarium haud productum, 0.8 cm. longem, 0.5 cm. latum, haud apice contractum. Calycis segmenta 4, triangulata, 1.0 mm. longa, appendices, 5–8 mm. longi, apice. calycis segmentis similes, apice stellato-setosi. *Petala* rotunda 1–5 cm. lata, rosea. Stamina 8, 1 5 cm. longa, anthero apice nec attenuatæ. *Ovarium* 6 mm. diametre, 5–10 loculare.

S. India on the Nilgiris, in and about Coonoor at 5–6000 ft. *Fyson* 5734.

Clearly distinguished by the pure pink of the petals and the long appendages of the calyx-mouth from the other Nilgiri species.

This plant was described and illustrated in the Flora of the Nilgiri and Pulney Hill tops, Vol. III as probably a good species, and considered by Mr. (now Rao Bahadur) K. Rangachari, the then Government Botanist as probably distinct. Apparently it was included by J. S. Gamble for his " Flora of the Madras Presidency " (p. 490–493) in O. octandra, but the colour of the flower, the long appendages, sessile bristle tufts and broader 5 ribbed leaves sufficiently distinguish it. The plant is figured in Vol. III of the N. and P. Fl. referred to above and in my forthcoming flora of the S. Indian Hill Stations.

3. **Notonia shevaroyensis** *sp. nov* (Compositae Senecionideæ) ab alteris specibus Indicis Notoniae foliis basi aggregatis et crasse dentatis parce carnosii differt.

Herba 25–80 em. alta. *Caulis* simplex erecta, glabra. Folia obovata as obtusa, 6-8 cm longer, 2. 5–3 cm. lata, basi ad petiolam angusta, glabra, semper inferiore violacea. *Corymba* circa 10 cm. diametro, glabra, ramis inferioribus 5·8 cm longis, ramis superioribus 1·2 cm. *Bractexe* 0. 5–0.3 cm. glabra lineae. Capitula 8–12 isogamea Phyllaria uniseriata, acqualia, cum paucis exterioribus parvis. 5-6 cm. long, lanceolata, glabra, marginis scariosis. *Flores* omnes similes,

Corolla tubulosa lobis triangulatis, lutea. *Antherae* basi integrae, apice, scariosae, longi-acuta vel acuminatae. *Styli* exserti, ramis apice obtusis. *Achena* cylinderica breviter setosa. *Pappi* setae 9–10 mm. longae, albae.

South India on the Shevaroy hills at 4500 ft. in swamp. *Flr.* June–January. The leaves are slightly fleshy, generally violet underneath.

Quite different from other Indian species of Notonia, and in its rather scapigerous habit similar to some forms of *Emilia scabra* Dc. (var. *scabra* of E. Sonchifolia *Wight* in *F.B.I.*)

Smilax zeylanica Linn. The three species, S. zeylanica macrophylla Roxb., and S. Wightii Dc are in the Flora of Madras Presidency included under the first name. It is possible that S. macrophylla Roxb. and S. Wightii DC should be united, for the difference between them is slight, though distinct enough in the specimens I have seen in the field.

A form on the Shevaroy Hills, which I take to be Smilax zeylanica, Linn., is, however, quite distinct in having the young fruit oval, about one and half times as long as wide, and when ripe distinctly ovoid, with a broad base. Trimen in his Flora of Ceylon describes S. zeylanica as having subglobose fruits, and I cannot but think that this is a real specific difference, but one easily overlooked in herbarium material. The differences between these species are shown in the figures of them in the Fl. S. Ind. Hill Station.

VIVIPARY IN ATRIPLEX CRASSIFOLIA AND SUEDA FRUTICOSA

BY

AMAR CHAND JOSHI.

Atriplex crassifolia C. A. Mey. and *Sueda fruticosa* Forsk. are two common plants of Lahore. The former grows abundantly near dwellings and cultivated soils, which have become rich in mineral salts by the decomposition of refuse and manure heaps. The latter can tolerate even a still larger amount of mineral salts in the soil and is one of the common plants of the *Kalar* soils. The common method of propagation in both these species is by seeds which when ripe fall off from the parent plant and grow in the soil. In December 1929, however, when the writer had gone out to collect some material of these plants for an anatomical study, he found the seeds of *Atriplex crassifolia* developing beyond the embryonic stage and germinating without undergoing any resting period even on the perfectly green parts of the plant. Some of the radicles which had pierced through the seed-coats, measured even a little more than one centimetre, about five times the length of the seed itself. On breaking open the seed-coats, it was found that in many cases the cotyledons had become green though these were still within the testa. The material was brought to the laboratory and photographed.

In December 1930, when the writer had again gone out on a similar purpose as before, viviparously growing seedlings were also observed on perfectly green shoots of *Sueda fruticosa*. These in their appearance and structure were quite similar to those of the first plant.

When the writer first discovered these viviparously growing seeds in *Atriplex crassifolia* he was inclined to regard it as an uncommon phenomenon. Later considerations, however, especially after the finding of viviparous seedlings in *Sueda fruticosa*, have made him believe that this may be of more common occurrence. The seeds of these two plants ripen in the month of December, which is rather a wet month in Lahore and their viviparous growth may be caused by such moist weather. It is, however, not certain whether these seeds, which germinate on the plant itself, do later on grow in the soil or play any appreciable part in the dissemination of these species.

Another point to be considered in this connection is the fact that these two plants, *Atriplex crassifolia* and *Sueda fruticosa*, are halophytes and many plants closely related to them grow on the seashore, the region where the phenomenon of vivipary is most conspicuously displayed. To the writer's knowledge, however, it has not been described in any of the Chenopodiaceæ growing there, but its occurrence in two Lahore Chenopodiaceous genera makes it probable that it may also be found there. That it has not been recorded so far, may be due to the small and insignificant size of their seeds. The rare occurrence of the phenomenon of vivipary in the Lahore plants, under favourable weather conditions, may then be a relic of their former home on the sea-shore; or, and this appears to be more probable, as has been more fully discussed by the writer elsewhere, Journal of Ecology, vol. XX, 1932 (in press), the viviparous habit of the seashore plants may have been derived from such occasional variations in other places.

BOTANY DEPARTMENT,
UNIVERSITY OF THE PUNJAB,
LAHORE, *Dated, 5th June, 1931.*

A. C. Joshi—Vivipary in Atriplex and Sueda.

Atriplex crassifolia. Part of the inflorescence, showing seeds, germinating on the plant. About natural size.

STRUCTURE, ARRANGEMENT AND COURSE OF VASCULAR BUNDLES IN THE STEM AND LEAVES OF HEPTAPLEURUM VENULOSUM SEEM

BY

AMAR CHAND JOSHI.

Introduction.

Heptapleurum Gaertn. is an Araliaceous genus. Its about 60 species are distributed all over the Old World tropics, but the only species occurring in northern India is *Heptapleurum venulosum* Seem. The writer's attention was first drawn to this plant from a casual study of the transverse section of the petiole which showed a peculiar arrangement of the primary vascular strands. These are arranged in two rings and the bundles of the inner ring show an inverse orientation to those of the outer ring. A similar transverse section of the stem revealed the presence of cortical bundles. As it was thought that a full knowledge of this peculiar arrangement of the bundles in the leaves and the stem, how it arises and its probable significance, would be of some interest, the present investigation was undertaken.

Previous Work.

Solereder (7) mentions a large number of workers who have investigated the central cylinder of the Araliaceæ. Among these are included Trécul, Sanio, Cedervall, Van Tieghem, Weiss, Güssow, Viguier and several others. All the earlier literature is cited by the last named author (8) and his researches along with those of Güssow (1) are the most comprehensive ones on the subject, though these were undertaken only from the systematic point of view and are accompanied by a large number of keys based on anatomical characters. Both of them used a very large number of plants in their investigations, Güssow about 43 genera and Viguier more than 60 genera. None of these authors, however, says anything about the structure of *Heptapleurum venulosum*. The only work in this direction has been done by Petit and Plitt (also quoted by Solereder) who have described the above mentioned peculiarity in the structure of the petiole. These investigators, however, restrict themselves to the structure of the petiole alone.

Habit and External Form.

According to Parker (6) *Heptapleurum venulosum* is met with in a wild state in the Sutlej and Ravi valleys but several cultivated plants are found in the various gardens of Lahore and the material from the latter has been used in the present investigation. The plants growing in Lahore usually assume the form of erect or suberect shrubs, with fairly large, alternate, stipulate and digitate compound leaves. The petiole is 6 to 9 inches long, dilated and clasping at the base. The stipules may be up to half an inch long and these are connate between the stem and the petiole. Leaflets are 3 to 7 in number, usually 5, 4 to 8 inches long and 2 to 4 inches broad. Their petiolules vary from half an inch to two inches in length. The middle leaflet is usually the largest. In their natural habitat, the plants flower in the months of January and February but in Lahore the flowering shoots make their first appearance in May and the flowers open in the month of June.

Structure of the Petiole.

The petiole is quite circular in cross section and as has already been told the vascular bundles here are arranged in two definite rings (fig. 1). Those of the outer ring are of two types. There are larger bundles mostly alternating regularly with smaller bundles. The structure of the two is, however, exactly similar. Each bundle consists of xylem and phloem. Xylem is internal and endarch and phloem external. To the outside of the phloem there is a cap of fibrous elements. These fibres are of the nature of substitute fibres. Their walls are greatly thickened and lignified but the protoplasmic contents are quite intact, as is characteristic of most herbaceous plants. The bundles of the inner ring are situated only opposite to the smaller bundles of the outer ring. Their number, consequently, is only one half of that of the bundles of the outer ring. Xylem and phloem of these internal bundles are arranged in a manner inverse to that of the bundles of the outer ring, the xylem here being external and phloem internal. Further these bundles lack the cap of fibres which is present to the outside of the phloem of the bundles of the outer ring. In one case only a deviation from the above arrangement was observed. Here a collateral vascular strand was found lying even inside the inner vascular ring without any definite position.

Resin canals which are characteristic of the family are situated in the petiole in a more or less definite manner. There are two rings of resin canals in the cortex, one near the periphery and close to the epidermis and the other close to the central cylinder. Further there is one resin canal to the inside of each of the larger vascular bundles of the outer ring.

A study of the cross-sections of the petioles of different ages shows that the larger bundles of the outer ring begin to develop earlier and then later on in between them are formed the smaller bundles. The bundles of the inner ring develop simultaneously with the latter. All these bundles, however, whether of the outer ring or of the inner ring, whether smaller or larger, develop from separate procambial strands and there development is quite normal, agreeing in every feature with that of the collateral bundles of an ordinary dicotyledon and such as is usually described in text-books. The xylem and the phloem begin to differentiate simultaneously at two opposite ends of the procambial strands, the middle portion of the procambium gives rise to the cambium and primary and secondary xylem are distinguishable. In the mature condition, however, although the smaller bundles of the outer ring and the bundles of the inner ring develop from quite separate procambial strands, the two become connected and appear to be situated within a more or less common sheath (fig. 10.) The walls of the cells intervening between the two bundles get thickened and lignified and these cells in a cross-section show the same structure as is shown by the cells of the fibrous caps of the bundles of the outer ring. Also the cells surrounding the inner bundles on the other sides get somewhat thickened and lignified. A sheath of lignified tissue surrounding the two bundles is thus differentiated and the whole thing assumes some resemblance with the internal bundles such as have been described in the stem of several perennial species of *Rumex* by Herail (2) and others. The resemblance is, however, only superficial, for as Maheshwari (5) has shown the internal bundles of *Rumex* develop from the same procambial strands from which the bundles of the outer normal ring are formed.

Course, Structure and Development of the Bundles in the Leaflets.

At the distal end of the petiole, the ring of vascular tissue, splits up into as many parts as the number of leaflets borne by it, so that a transverse section of the petiolule of a leaflet (fig. 2) shows an arc of bundles, several of which have internal bundles. In other words two arcs of bundles can be distinguished here also, as two rings in the main petiole, an outer and an inner one. The bundles of the outer arc are normally orientated and those of the inner one inversely orientated. In the outer arc larger and smaller bundles can be distinguished and most of the bundles of the inner arc are situated opposite to the smaller bundles of the outer arc, but the arrangement is not so definite as in the petiole. This is caused by some of the internal bundles turning through an angle of 180 or less degrees and uniting

with the bundles of the outer ring. Sometimes the arrangement of the bundles is such that in a transverse section there appears to be an outer bundle with an internal bundle and some bundles situated on the sides of the two (fig. 11).

Higher up where the petiolule begins to pass into the blade of the leaflet (fig. 3) the side bundles of the arc begin to pass outwards into the assimilatory region of the blade and only the central ones remain in the midrib. Further up, as one passes to the distal end of the leaflet, one finds the internal inversely orientated bundles all one by one turning through a smaller or bigger angle and fusing with the bundles opposite to them, so that all the bundles become normally orientated. The adjacent bundles begin to fuse with each other and the number of bundles decreases so that about the middle of the blade of the leaflet, in the region of the midrib, only a few large bundles are present and these are arranged in a deep arc the margins of which are turned inwards (fig. 4). Near the apex of the leaflet, all these bundles fuse and a single crescent-shaped vascular strand is formed. (fig. 5).

As regards the development, it may be mentioned that some of the bundles in the region of the petiolule show a different situation as compared with the normal development of collateral bundles, such as is found in the petiole and the stem of this plant also. The procambial strands here often only give rise to phloem. Then a cambium is differentiated on one side and all the xylem develops from this cambium, so that primary xylem is altogether eliminated. In such cases (fig. 11), a certain amount of resemblance is shown with the medullary phloem of certain families like Cucurbitaceae. Fig. 11 for example may be compared with text-fig. 4 of Holroyd (3). There is, however, a good deal of difference in the origin of the internal bundles in the two cases, for in the Cucurbitaceæ the inversely orientated internal and lateral bundles develop from the same procambial strands as the bundles of the outer ring.

The Course of the Bundles at the Base of the Petiole and in the Stem.

At the base of the petiole, the smaller bundles of the outer ring begin to pass inwards and the bundles of the inner ring either join the bundles of the outer ring opposite to which they are situated or simply turn through an angle of 180 degrees so that they lose their inverse orientation. In this way a transverse section of the base of the petiole (fig. 6) shows a large number of irregularly scattered bundles like those of a monocotyledonous stem, the majority of which are normally orientated and only a few here and there show inverse orientation.

Lower down the petiole joins the sheathing leaf base and the whole mass of bundles coming from the leaf begins to open out from the inner side (fig. 7) and gradually resolves itself simply into a ring of bundles surrounding the ring of primary vascular strands of the stem, when the leaf and the stem have fused (fig. 8). These foliar bundles do not join the bundles of the stem all at once. On the other hand they do so very gradually. No one leaf gap is formed but the bundles of the leaf trace pass into the central cylinder from all sides. The leaf trace consequently may be called multilacunar. This along with the sheathing leaf base are monocotyledonous characters. Further these leaf trace bundles do not pass into the central cylinder all at the same level. The foliar bundles on the side of the stem, away from the side on which the leaf is attached, pass first into the central cylinder (fig. 9) and then the other bundles slowly and slowly. It is only when the lower node has been reached that all the foliar bundles pass into the central cylinder. This explains the presence of cortical bundles in a cross-section of the stem.

The structure of the flowering peduncles is essentially similar to that of the vegetative stem and cortical bundles are present here also.

Discussion.

The chief features in the anatomy of *Heptapleurum venulosum* are, firstly, the scattered disposition of the bundles at the base of the petiole, their arrangement in two rings through the greater length of the petiole and the inverse orientation of the bundles of the inner ring; and secondly, the occurrence of cortical bundles in the stem, due to a longitudinal course of the leaf trace bundles in that tissue. Similar abnormalities have also been described in other genera of the Araliaceae. Viguier (8) mentions about 30 genera which have got medullary bundles in the petiole. Güssow (1) mentions about 10 genera which have medullary bundles in the stem. Cortical bundles have been described in the stem of several genera like *Mydocarpus*, *Delarbrea*, *Heteropanax*, *Cussonia*, *Oreopanax*, *Pentapanax* and *Stilbocarpa*. Both medullary and cortical bundles are found in some cases. In no case, however, these bundles have been investigated in detail and their course described with the aid of modern technique. Nor any attempt has been made in this family to explain the significance of these structures which, although fairly common in some orders, are really deviations from the normal vascular cylinder of the dicotyledons.

A few years back Worsdell (9, 10) studied the anatomy of the Cucurbitaceæ and Compositæ, from which he arrived at some general conclusions applicable to the whole group of Angiosperms with the possible exception of the Amentiferæ. According to him the medullary

bundles or a scattered disposition of the bundles, such as is found in monocotyledons, is an ancient character of the stem of flowering plants, which the monocotyledons have mostly retained and dicotyledons have mostly left behind. The medullary phloem found in the axis of some orders of dicotyledons is the last vestige of this ancestoral condition. Most of his evidence is drawn from a study of the petioles and the flowering peduncles which are regarded as conservative organs and are supposed to retain the ancestoral structure—medullary bundles or a scattered disposition of the bundles—more or less well preserved when it has become extinct or almost so in the stem.

Worsdell did not use the evidence from the anatomy of *Heptapleurum* or any other Araliaceæ in support of his conclusions, but he could have easily utilised it. In *Heptapleurum* medullary bundles are absent from the stem but these are found in a quite well developed condition in the petiole. Similar condition is also exhibited by several other genera of the Araliaceæ. *Aralia spinosa* possesses a ring of inversely orientated medullary bundles in the petiole, while these are absent from the stem, though found in the stem of several other species of *Aralia* and *Arthrophyllum*, according to Solereder (7). Similarly from the work of Viguier (8) and Güssow (1), one finds the absence of medullary bundles in the stem of *Schefflera* and *Didymopanax* and their presence in the petiole. There is, however, one feature which is not explainable on the basis of Worsdell's conclusions. His theory can explain the absence of medullary bundles in the stem and their presence in the petioles of several plants, but he has no consistent explanation to offer for such a condition as is found in *Heptapleurum venulosum*, where medullary bundles are found in the petiole and in their stead cortical bundles in the stem ; and this little point can change our whole outlook on the question and make one seek some other explanation.

Opposed to Worsdell's theory, are the views of several other botanists who regard the medullary bundles in the stem of decotyledons as a new formation which originated as a response to certain physiological needs. Various causes have been mentioned and perhaps the evolution of medullary bundles in different groups is due to different causes. One of the most plausible causes has been mentioned by Jeffrey (4). He believes that there has been a gradual increase in the elaborative efficiency of the leaves from the earlier to the modern flowering plants and " this situation has brought about that many traces enter the stem at a node instead of three or at the most several traces which pass into the nodal region of the axis in the mass of dicotyledons. This multiplication of the conducting strands brings with it complications of arrangement in the stem for the number is too large to be accommodated on the periphery in a single ring as is the

rule even among herbaceous dicotyledons. As a consequence of the necessities which have thus arisen the leaf traces are displaced from the margin of the central cylinder into the pith or medulla. Rarely the same object is effected by the running of the foliar traces for one or more internodes in the cortex."

After considering both these views about the nature of medullary bundles with special regard to the anatomy of *Heptapleurum venulosum*, I feel inclined towards the second one. The leaves of this plant are fairly large. I have not investigated their elaborative efficiency, so I cannot say anything on this point. The number of the leaf trace bundles, however, is very large and one actually sees while tracing the course of vascular bundles how congested these structures are both in the petiole of the compound leaves and in the stem, a fact also borne out by the very gradual passing of the leaf trace bundles into the central cylinder. This view further has the merit of explaining medullary bundles in the petiole and cortical bundles in the stem in accordance with one uniform principle.

As regards the inversely orientated bundles, Worsdell (9, 10) believes these to have been derived by reduction from amphivasal concentric type of bundles which he regards to be the most ancient form of vascular bundle in the Angiosperms. In *Heptapleurum*, however, one sees how easily while passing from the base of the petiole higher up, a normally orientated bundle becomes inversely orientated, simply by turning through an angle of 180 degrees. This suggests that in some plants at least inversely orientated bundles have not been derived from amphivasal bundles by reduction but by a simple rotation of the ordinary collateral bundles and these peculiar arrangements in most cases may be simply regarded as variations in design, all fulfilling the same need.

In the end it may be suggested that a comprehensive study of the course of the primary vascular strands in the leaves and the axis of the various genera of the Araliaceæ would be of great value in properly understanding the nature and origin of medullary bundles, not only in this but in other orders of dicotyledons as well.

Summary.

1. The vascular strands in the petiole of *Heptapleurum venulosum* are arranged in two rings. Those of the outer ring are alternately large and small. The bundles of inner ring are inversely orientated and situated opposite to the smaller bundles of the outer ring.

2. In the petiolule there is an arc of alternately large and small bundles, the latter mostly having inversely orientated bundles on their ventral side.

3. At the base of the petiole all the bundles are irregularly scattered.

4. A large number of leaf trace bundles enter the stem at every node from all sides. The leaf trace is multilacunar and the leaf trace bundles take an almost perpendicular course in the cortex for a longer or shorter distance and so give rise to cortical bundles in the stem.

5. It is suggested that these abnormalities, cortical bundles in the stem and medullary bundles in the petiole are recent formations which have originated in response to physiological needs.

I desire to express my thanks to Professor S. R. Kashyap for his several valuable suggestions and criticisms.

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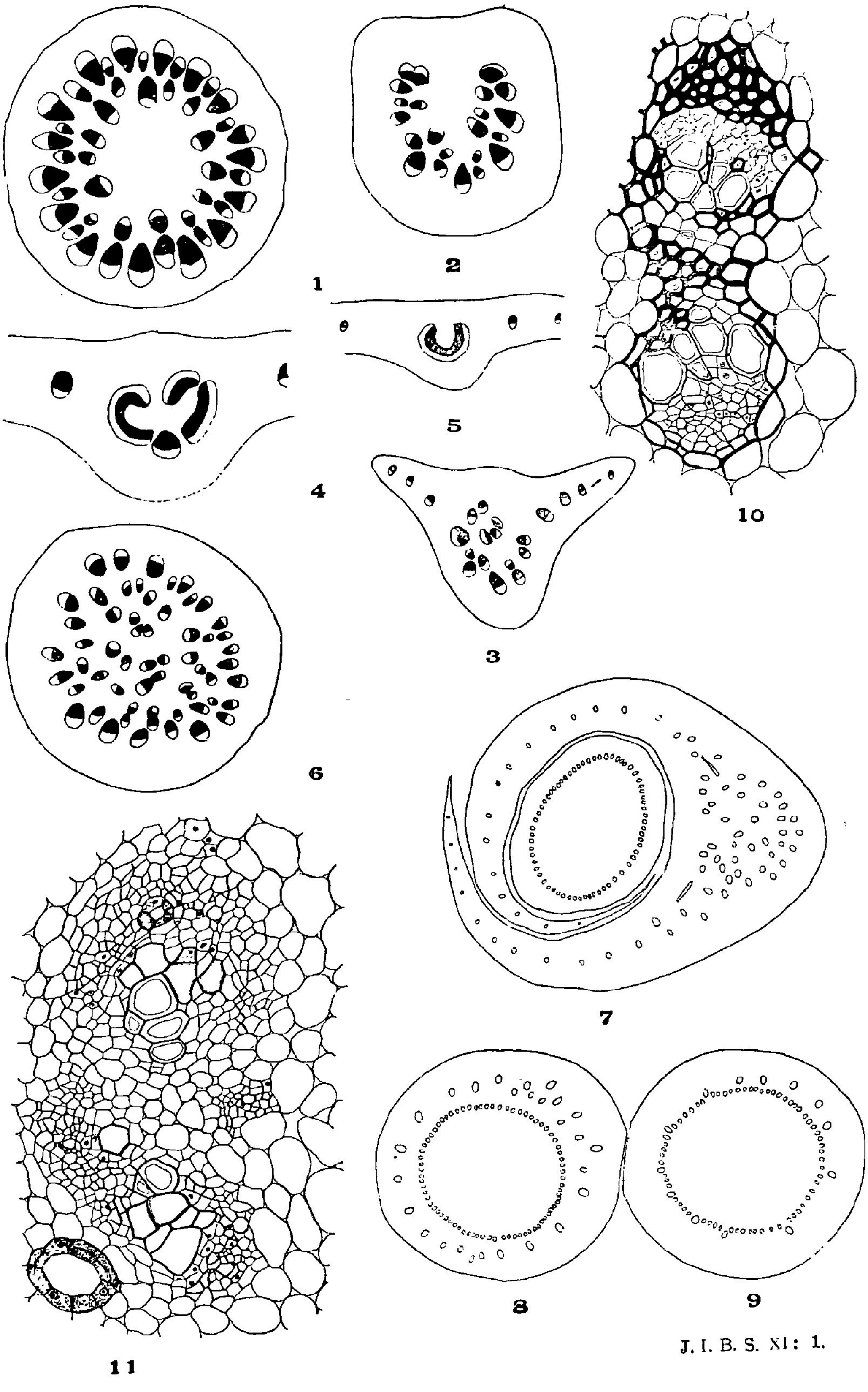
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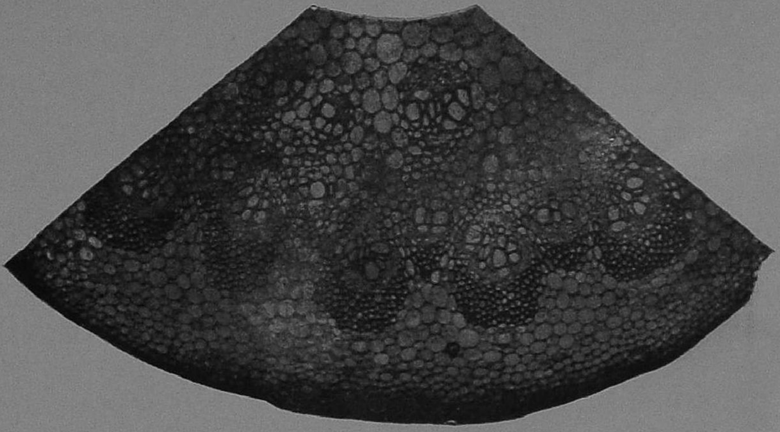


Explanation of Plates.

Fig. 1. Transverse section of the petiole, showing the arrangement of vascular bundles. Xylem in this and in figs. 2–6 is represented by black. × 20.

Figs. 2–5. Transverse sections of the leaflet at various places showing the arrangement of vascular bundles.

Fig. 2. Transverse section of the petiolule. × 25.

Fig. 3. Transverse section of the region where the petiolule just begins to pass into the blade of the leaflet. × 20.

Fig. 4. Transverse section of the mid-rib about the middle of the blade of the leaflet. × 25.

Fig. 5. Transverse section of the midrib near the apex of the leaflet. × 25.

Fig. 6. Transverse section of the base of the petiole showing the arrangement of the bundles. × 15.

Fig. 7. Transverse section of the stem and the sheathing leaf-base just above the node. × 17.

Fig. 8. Transverse section of the stem just below the node. × 17.

Fig. 9. Transverse section of the stem lower down. × 17.

Fig. 10. One external and one internal bundle from fig. 1, showing the structure of the two × 200.

Fig. 11. A part of the transverse section of the petiolule, showing an outer bundle with its internal and lateral bundles. × 200.

CHROMOSOME NUMBERS OF INDIAN CROP PLANTS.

(A) Chromosome Numbers in Jute.*

BY

I. BANERJI, M.Sc.

The importance of the study of the cytology of crop plants has been recognised in recent years and results of great economic value have been obtained in many cases. A knowledge of the chromosome numbers of the cultivated varieties of crop plants and their near relatives is a necessary preliminary to detailed cytological and genetical investigations. As apart from other considerations, it very often gives us an indication as to the amount of sterility one is likely to encounter in interspecific hybridisation. Investigations on the chromosome numbers of most of the European and American crop plants are complete, and detailed cytological work has been done on a number of plants. Asse and Powers (1) in 1926, published a list of crop plants whose chromosome numbers had been worked out. Further investigations since then, have added many numbers to the series and considerably increased the list. A detailed knowledge of the chromosome numbers of Indian crop plants and the various strains isolated, is far from complete as yet. Excepting cotton (2) and a few cultivated millets (5), very little information is available as to the chromosome complements of our cultivated crop plants. A beginning has been made in this laboratory to work out the chromosome numbers of Indian crop plants, and this paper is the first of the series.

Material and Methods.

The material used in this investigation has been grown in the University College gardens from selfed seeds obtained from the Agricultural Department, Bengal. Fixation was usually carried out in the afternoon and meiosis was noted to be just as frequent on cloudy as on sunny days. The following fixing fluids were tried :—Flemming's (weak), Allen's modified Bouin's, Carnoy's and Acetic-alcohol. The penetration of the first two fixatives appeared to be rather poor, Carnoy's fluid caused a good deal of shrinkage, but Acetic-alcohol gave uniformly good results. The material was always fixed in the field and kept in the fixing fluid (Acetic-alcohol) for thirty minutes, it was then dehydrated, and all trace of acetic acid removed, cleared either in several ascending series of Xylols, or in Cedar wood oil (3). Both these procedures gave satisfactory results. The material was finally embedded

* Contributions from the Department of Botany, Calcutta University.

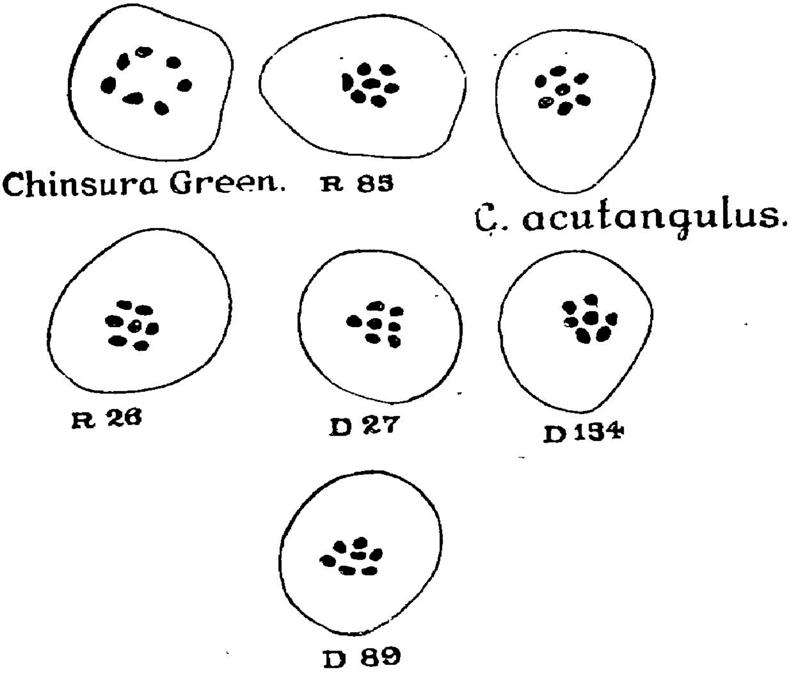
in paraffin. Sections were cut 8–10 microns thick, with the idea of obtaining complete cells in the sections which facilitates considerably the counting of chromosomes. Haidenhain's iron-alum hæmatoxylin has been used for staining.

Results.

The chromosome numbers of four agricultural strains of *Corchorus capsularis* and two of *Corchorus olitorius* have been determined, as also of *Corchorus acutangulus*—a weed which grows wild during the monsoon round about Calcutta. The chromosomes were counted from the meiotic stages of the microspore mother cells. Check counts were taken from a large number of flower buds to eliminate any possible source of error.

The haploid chromosome numbers as determined are given below

	(n)
1. *Corchorus olitorius Linn.*	
(*a*) R. 26	7.
(*b*) "Chinsura Green"	7.
2. *Corchorus capsularis Linn.*	
(*a*) D. 154	7.
(*b*) R. 85	7.
(*c*) D. 27	7.
(*d*) D. 89	7.
3. *Corchorus acutangulus Lamk*	7.



Text-figure. Chromosome numbers in jute. (× 2,250).

The chromosomes of jute appear to be very small in size and careful examination failed to show any difference in shape or size of the various types investigated.

Investigations on the chromosome numbers of the cultivated varieties, and of the wild jute were undertaken with the idea that it might throw some light on the purity of the different strains, as also, on the chromosome relationships in the genus *Corchorus*. No difference in the chromosome number was noted in all the types examined nor was any cytological irregularity found. Type D. 89 which is a *capsularis* variety and which according to Experiment station report was obtained from a cross between D. 154 and a Japanese variety obtained from Formosa Island, showed nothing in meiosis to suggest its hybrid origin. Conjugation between the two parental groups of chromosomes appears to have been complete in this case.

As compared to other plant families of economic importance, the family Tiliaceae has not received much attention from cytologists. The chromosome numbers listed for Tiliaceae by Gaiser (4) are *Entelea palmata* 8 (haploid) and *Sparmannia africana* 80 (haploid). These two plants were investigated by Stenar (6). The number seven obtained for the three species of *Corchorus* investigated show that there is no polyploidy in this family and the chromosome numbers in this genus appear to be quite stable.

Cytological investigations on the development of the male and female gametophyte in *Corchorus olitorius* and *Corchorus capsularis*, and also the process of fertilisation in jute is nearly complete, and a detailed communication will be made at an early date.

Summary.

Chromosome numbers of some agricultural strains of *Corchorus capsularis* and *Corchorus olitorius* were investigated as also of *Corchorus acutangulus*. The haploid chromosome number was found to be seven in all cases.

DEPARTMENT OF BOTANY,
UNIVERSITY OF CALCUTTA.
15th February 1931.

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THE GAMETOPHYTE OF EQUISETUM*

BY
PROF. S. R. KASHYAP.

The gametophye of *Equisetum* has usually been described in text-books as a small structure, bearing either antheridia or archegonia, distinctly dorsiventral, with generally a growing point at the apex and bearing lobes more or less horizontally arranged and becoming partly erect on account of the action of light. The male plants are said to be smaller and the female larger. In 1914 the writer described the structure and development of the prothallus of *Equisetum debile*. Roxb. (Annals of Botany, Vol. XXVIII, No. CIX, January 1914) from specimens found wild along the banks of the river Ravi at Lahore and from specimens obtained by growing the spores in the Laboratory, and he showed that in that species the prothallus is a hemispherical cushion which may be more than an inch in diameter at maturity, consisting of a lower compact portion and an upper spongy portion formed of numerous perfectly vertical branched and very compactly arranged lobes; that the prothallus had a ring of meristem all along the margin which formed the compact tissue below and the lobes and sex organs above, and which made it radial to that extent; and that the prothallus invariably formed archegonia at the base of the lobes first and the same prothallus produced antheridia later on along the margin with the suppression of lobe-formation. In another note in 1917 (Annals of Botany, Vol. XXXI, Nos. CXXIII and CXXIV, July and October, 1917) he stated that in the same species of Equisetum if the spores were sown very close together so that the prothallia were crowded, the latter remained very small and bore only antheridia, thus resembling the so-called male p'ants. If the prothallia were grown away from each other with plenty of space and food they were like the normal prothallia found in the wild condition, that is, they formed hemispherical cushions with a meristem all round and bore archegonia. In this paper he wrote as follows:—

"In other experiments the spores were grown thickly. In these it was observed that the prothallia grew in thick clusters and remained very small even after two to three months. They

* Walker, Elda R.: The Gametophytes of three species of Equisetum, Bot. Gaz., Vol. XCII, No. 1, September, 1931.

showed a distinctly apical growth and the meristem was restricted to one part of the margin. Naturally the prothallia were elongated antero-posteriorly, and the largest were about one millimetre in length and considerably less in width. They bore archegonia or antheridia. The occurrence of antheridia alone on the prothallia is interesting, as they are never found alone in the prothallia growing at a distance from each other in the laboratory or in the wild state. In the latter state the prothallia are always scattered, clusters never having been observed. In the scattered prothallia archegonia are always formed first and antheridia arise only on the older prothallia. The prothallia arising in clusters from thickly sown spores are thus extraordinarily similar to those of other species of *Equisetum* figured by Buchtien and others. The lobes, however, in the prothallia of *Equisetum debile* are always erect in whatever condition the prothallia may be growing, thus differing from the lobes of those of other species which are spreading. It is possible that in some cases at least the prothallia of other species of *Equisetum* remain small owing to the spores having been sown thickly. It would be interesting to find out the behavior of the spores of some other species of *Equisetum* when sown far apart."

The prothallia were also kept growing for more than 10 months.

In 1921 Walker described the prothallium of *Equisetum laevigatum* (Bot. Gaz., Vol. 71, No. 5, May 1921). The author states in that paper that the gametophytes found by the present writer very closely resembled those of *Equisetum laevigatum* and her figures show that the resemblance between the gametophytes of the two species is really extraordinarily great. She describes the gametophytes of *E. laevigatum* as consisting of a flat circular disk, 1 to 10 mm. in diameter, bearing numerous upright green branches on their upper surface and surrounded by a band of meristem which continues the growth of the thallus and produces archegonia and antheridia, and typically monoecious. In the paper under consideration published in September 1931, the writer has studied the gametophytes of three species of *Equisetum* from specimens grown in the laboratory from spores and from specimens found wild. The three species are *E. kansanum*, in which the gametophyte closely resembles the gametophyte of *E. laevigatum*, *E. telmateia* and *E. arvense*. The results strikingly confirm the present writer's anticipations as given in the paragraph quoted above from the Annals of Botany. She finds that all the three species agree with *E. debile* and *E. laevigatum* in being characteristically monoecious. The thalli that have usually been considered male

plants are only the crowded and greatly dwarfed individuals. Those that have been considered female are normal individuals which form both archegonia and antheridia. In all the species these normal plants characteristically produce first archegonia and then antheridia. The gametophytes of all species agree in their early development and at maturity in having a massive base and meristematic rim and upright green branches. The upright green branches are characteristically different in each of the species. In *E. kansanum* they resemble the erect branches of the prothallus of *E. debile*. In the other two species they are flat. On normal thalli it is usual for archegonia to develop first, then antheridia; still later archegonia may again develop, followed by antheridia. In all species archegonia and antheridia are borne on the massive tissue of the main axis or of its lobes. Only rarely do antheridia occur on the upright branches. Normal thalli are monoecious. Dwarfed and starved plants produce only antheridia. Archegonia develop from meristem that is forming upright green branches and many rhizoids, and at maturity lie between these branches. Antheridia develop from meristem which is forming reduced branches or none, and few or no rhizoids. At maturity they occupy expanded chlorophyll-free regions. Following the development of antheridia, the thallus rests for a time before again developing archegonia. Cultures of *E. kansanum* and *E. telmateia* have been under continuous observation for two years; those of *E. arvense* for eight months.

LAHORE,
11th December, 1931.

A NOTE ON THE OPENING OF THE FLOWERS OF PORTULACA TUBEROSA

BY

A. B. SARAN, M.Sc.

One morning in the month of December, 1930, it was noticed at 9 a.m. that the flowers of the pots which were in direct sunlight, were more or less fully opened and the flowers of those pots which were in shade, were partially opened. This prompted me to perform the following experiments and to make the following observations in order to find out the condition under which the flowers open.

Experiment No. 1, December 7th, 1930.

(*a*) At 6-30 a.m. two pots, whose flowers were still in bud, were removed from outside and were placed in a corner of a room. A 60 W. electric bulb was lighted at a distance of 6 inches over two buds in one pot. The other pot was kept at a distance of 30–32 inches from the bulb. After an hour it was noticed that several buds besides the two in question had opened out. The temperature near those two flowers over which the bulb was burning was 29. 5°–30° C and the temperature at a distance of 9–11 inches was 28° C. At 4-30 p.m. that is, after 9 hours, it was noticed that those flowers which were at a distance of 9–11 inches began to close up and in half an hour's time they closed up completely. The temperature at 5 p.m. at a distance of 10 inches from the bulb was 26.5° C. But those flowers, which were just below the bulb remained open till 7-30 p.m. At 7-45 p.m., a closing up tendency in these two flowers was noticed and at 8-30 p m. the flowers closed up. The temperature at 8-30 p.m. near those two flowers was 29° C. The temperature of the room at the beginning of the experiment was 21° C. and that at 9 p.m. was 19° C.

(*b*) It was also noticed that the branches had bent towards the source of light. To make sure whether the bending of the branches was brought about by a change in temperature, the bulb was next wrapped up by a tin foil and then the whole thing was wrapped up by a thick black paper and it was made sure that no light was leaking out and the switch was put on. It was found that in half an hour's time the branches bent towards the bulb. When the light was put off, the branches within 3 minutes' time assumed their original position.

(c) The buds of the second pot which was at a distance of 30–32 ins. away from the bulb, did not open at all. Next morning the same bulb was lighted just over two buds at a distance of 6 inches, and it was noticed that several buds besides the two in question opened out. But almost all of them closed up completely after 3 hours' time : although under normal condition they remain open on these days (4th December, 20th December), for 6–7 hours. At the time when the flowers were closing up, the temperature near those two flowers over which the bulb was burning was 30° C.

Experiment No. 2, December 18th, 1930.

A flower pot was kept in the dark room in the evening Next morning just over two buds from a distance of 6 inches a 60 W. bulb was kept burning. Before the light was put on, a glass dish containing about ¾ of an inch of water was kept in between the bulb and the buds. There was a constant flow of water in the dish. This was done to cut off the heat rays. The buds were kept in this condition for over two hours, but they did not open. The dish was removed and after an hour the buds opened out fully.

Experiment No. 3, January 8th, 1931.

Some buds which were expected to open the next morning, were slipped in along with the branches into a light-proof bag in the night. It was found at 10 a.m. next morning that the buds within the bag had opened out completely.

Experiment No. 4, January 12th, 1931.

In the dark room, an experiment was set up in the same manner as in Exp. No. 1, but the bulb which was wrapped up by a tin foil was kept burning at a distance of 14″ from two buds. It was found that the buds did not open even after two hours. The temperature near the two buds was 25° C. The bulb was gradually lowered down till a temperature of 27° C was reached near those two buds. It was noticed that at this temperature the flowers opened out. After two hours' time when the flowers were still open, the bulb was still lowered down and the temperature near those two flowers became 35° C and the flowers closed up completely in quarter of an hour. By regulating the distance of the bulb from the flowers, it was found out that the flowers remain open at any temperature between 27° C and 33° C. But when the temperature exceeds 33° C, there is always a tendency towards the closing of the flowers.

Experiment No. 5, April 14–17, 1931.

On these days the flowers remain open for 3–4 hours. They generally close up at about 11 a.m. when the temperature in the sun is about 35° C.

Conclusion.

(1) That the opening of the flowers in Portulaca tuberosa is brought about by a change of temperature, the change being from lower to higher and that at any temperature between 27–33° C. the flowers remain open.

(2) That the maximum period during which the flowers can be made to remain open artificially is about 12 hours, *vide* Exp. I (a), Under natural conditions in winter they remain open for about 6 hours and in summer for about 4 hours. In winter the closing up of the flowers in the evening is due to a fall in temperature, but the early closing up in summer is due to higher temperature.

(3) The buds which are not allowed to open at the due time, can be made to open by supplying the favourable condition but for a shorter duration *vide* Exp. I (c).

(4) The branches of this plant are also sensitive to temperature and they are positively thermotropic. Exp. 1 (b).

I wish to express my grateful thanks to Prof. P. K. Parija, I.E.S., for his guidance and suggestions throughout the course of this investigation.

DEPARTMENT OF BOTANY,
RAVENSHAW COLLEGE, CUTTACK.

A SIMPLE METHOD OF ILLUSTRATING MENDELIAN INHERITANCE

BY

B. B. MUNDKUR.

In a recent issue of this Journal, Ajrekar (1) has outlined a method for demonstrating Mendelian inheritance involving one or two pairs of factors to elementary classes in Genetics. It consists in taking glass beads of different colours, sizes and shapes, mixing them in a bag, and taking out at random one or two pairs as the case may be and recording the results in a suitable manner. The method illustrates the principle of random mating and the operation of the law of chance.

A simpler method than the one described by Ajrekar has been referred to by Sinott and Dunn (2). Briefly it consists in taking, for monohybrid ratios, two coins preferably two quarter anna pieces and tossing them a hundred or more times. The heads may be designated by the letter H and the tails by the letter h. The throws will arrange themselves into three groups, heads heads, heads tails, and tails tails or as HH, Hh, and hh. The exercise will show with equal precision the principle of random mating and the operation of the law of chance. The lettering as suggested above will also introduce the students to the concepts of homozygosity, heterozygosity, phenotypes and genotypes.

For dihybrid ratios two copper coins and two silver coins tossed together as above will be found to be extremely satisfactory. The symbols may be :

Copper : heads H, tails h

Silver : heads S, tails s

The throws will arrange themselves, or in the language of the geneticists, segregate as follows :

1	H H	S S	All heads
2	H h	S S	Copper head and tail, Silver all heads
2	H H	S s	Copper all heads, Silver head and tail
4	H h	S s	Copper head and tail, silver head and tail
1	H H	s s	Copper all heads, silver all tails
2	H h	s s	Copper head and tail, silver all tails
1	h h	S S	Copper all tails, Silver all heads
2	h h	S s	Copper all tails, silver head and tail
1	h h	s s	All tails

Each student may be asked to make a hundred throws or more and to record the observations as above. Whatever numbers the individual students may obtain and however much they deviate from calculated numbers, if the instructor writes on the black-board the classification of the throws and records under each head the figures obtained by the students and adds them up, it will be observed how slightly the totals under each genotype depart from the calculated numbers.[2]

For the ease of operation and the simplicity of materials needed, this method is hard to beat.

1. AJREKAR, S. L.—A simple method of illustrating Mendelian monohybrids and dihybrid ratios. Jour. Ind. Bot. Soc. 9 : 62–64. 1930.

2. SINOTT, E. W., AND L. C. DUNN. Principles of Genetics, McGraw-Hill Book Cmopany, New York, 1927.

THE FLOWERING PLANTS OF MADRAS CITY AND ITS IMMEDIATE NEIGHBOURHOOD

BY

P. V. MAYURANATHAN,

Bulletin of the Madras Government Museum, Government Press, 1929.

One of the great needs of modern botany in India and of those who are interested in Indian field botany is the publication of small portable local floras dealing with limited areas which may enable one to easily determine the correct names of the p'ants growing in that locality. Few such books are available at present and all, especially the residents of Madras, would be thankful to Mr. Mayuranathan for writing out and the Superintendent of the Madras Government Museum for issuing this flora of Madras City and its immediate neighbourhood.

The book has been prepared with the object of helping even the non-specialist to identify the Flowering Plants growing in the neighbourhood of Madras city. Grasses have been omitted on account of the minute size of their flowers and the great difficulty that they present to the non-specialist. In the beginning of the book there is an artificial dichotomous key for families and some of the aberrant genera like *Euphorbia*. This is followed by the description of families, genera, and species with the various subsidiary keys on the dichotomous plan. The descriptions are brief and clear. No hard technical terms are used and for the few technical terms used there is a glossary. Flowering periods of most of the species are given and English, Tamil and Telugu names are another important feature of the book. Besides a general index to families, genera and species, there are separate indices to English, Tamil and Telugu names. In all about 1,200 species are described and about one-sixth of these are well illustrated.

The book is rather bulky and it would probably have been more useful and certainly more handy and convenient to carry about if it had been of a smaller size and of less weight. This could have been achieved by using thin paper of a smaller size. All the same we congratulate the writer on the preparation of this excellent volume and wish there were more of that sort for other parts of the country.

A. C. J.

ICONUM BOTANICARUM INDEX LONDINENSIS

BY

O. STAPF,

Oxford Clarendon Press, 1929–1931.

Every botanist recognises the need and appreciates the use of good illustrations as a companion of any accurate descriptive work in the sciences of Botany and Horticulture and numerous figures have appeared by now either as separate plates or as text figures. These are scattered throughout the world's scientific literature, so that the need of their being systematically indexed has always been felt. In 1855 Pritzel undertook such a work and his Iconum Botanicarum Index Locupletissimus, along with its supplement, containing references to the end of the year 1865, has always been a very useful work of reference. Owing to the accumulation of new material, however, it had been felt for sometime that to keep up the usefulness of this work it should be brought up to date, but by this time the number of published illustrations had become so large that it had become impossible for any person to take up such a task alone. Consequently, it was taken up by the Council of the Royal Horticultural Society of London in 1909. In July 1918 Stapf was appointed as the Honorary Editor and the work begun at the Herbarium of the Royal Botanic Gardens, Kew. Now this work has been completed and published in six attractive volumes.

The work gives references to all the illustrations whether text-figures or plates, published up to the year 1920 and its immense importance scarcely needs any emphasis. It has already proved a valuable supplement to the Index Kewensis by the registration of the plant names not included in the latter and by giving extensive cross-references which connect older abandoned names with their modern equivalents. It has further demonstrated its usefulness by giving innumerable clues to literature buried in books and periodicals, which would *prima facie* not suggest itself to the 'pure' botanist or horticulturist.

A great need to keep up the usefulness of such works, however, is the publication of supplements, from time to time, cataloguing the new material. We understand that the Editor of this work is already engaged in writing out a supplement which will take the work to the year 1935. The undertaking deserves all help from botanists and institutions all over the world.

A. C. J.

THE INDIAN SPECIES OF THE GENUS CARALLUMA.
(Fam. Asclepiadaceae)

BY

F. H. GRAVELY AND P. V. MAYURANATHAN,

Bulletin of the Madras Government Museum, Government Press, 1931.

As the authors point out the genus *Caralluma* is one of those genera which present great difficulties to the herbarium worker due to several important characters becoming unrecognizable in the dry state; and although the genus as a whole was admirably revised by Berger in 1910, his treatment of the Indian species still needed supplomenting by local observations. This task the present authors have done most admirably and their observations are authoritative in as much as they are based not only upon dry herbarium material and plants growing wild but also upon a successful cultivation of most of the species in the garden for several years. Some of the important differences between their arrangement and that of the Flora of British India are the following :

Following Schumann and Berger the authors have included the genus *Boucerosia* Wight and Arnott under the genus *Caralluma* Br. and divided the latter into three sections *Eucaralluma, Lalacruma* and *Boucerosia*. The second section is unrepresented in India. *Eucaralluma* includes three species, *C. edulis, C. adscendens* and *C. stalagmifera*. The last was described by Fischer only a few years ago from material sent by one of the authors of the present monograph. The second species, *C. adscendens* includes six varieties : three species of Hooker, namely *C. adscendens, C. fimbriata* and *C. attenuata*, which now get the rank of varieties, and three new varieties, *gracilis, carinata* and *geniculata*. The section *Boucerosia* includes 8 species one of which, *Caralluma (Boucerosia) procumbens* is new. All the species and varieties are well illustrated.

Another conclusion to which the authors have come from their study of this genus is with regard to the origin of new species in this family. N. E. Brown in 1890 had concluded that new species in the Asclepiadaceæ have been very commonly produced by hybridisation. The present authors find little evidence of hybridisation in the Indian species.

A. C. J.

FLORA OF SIAM.*

The fourth contribution to the "Flora Siamensis Enumeratio" by W. G. Craib has been published under the auspices of the Siam Society and this completes the first volume dealing with the Polypetalae. The first part was published in the year 1925, part 2 in 1926 and part 3 in 1928. On the title page of the 4th part it is put down that it deals with the families Rosaceæ to Cornaceæ, but the family Nyssaceæ is also included. 666 species are enumerated. These are distributed into 151 genera. Melastomaceæ with its 17 genera and 124 species is the largest family described in this part. *Eugenia* with its 89 species is the largest genus. Four families, viz., Callitrichaceæ, Crypteroniaceæ, Caricaceæ and Datiscaceæ are monotypic. No new species are described. This is due to the fact that the author along with Geddes and others had published from time to time all such species a little earlier in the *Kew Bulletin.* About 65 new varieties, however, have been created and their Latin descriptions given. Four species, two belonging to the Rosaceaæ and two to the Myrtaceæ have been given new names. Complete records of the localities from which the different species are known and their local names are a special feature of the volume and the whole work should certainly prove useful to students of tropical vegetation.

A. C. J.

* Craib, W. G. Floræ Siamensis Enumeratio. Vol. I, Part 4, Rosaceæ–Cornaceæ, Bangkok, 1931.

We have received the following communication from Mr. Fischer in connection with the Flora of the Presidency of Madras and wish to bring it to the notice of all interested in the subject :—

Flora of the Presidency of Madras.

As the above Flora is approaching completion, I shall be much obliged for any errors and omissions that are brought to my notice. In the case of omitted species and genera, I must adhere to Mr. Gamble's rule and only admit those that are supported by duly localised specimens.

It is proposed to publish corrections and additions in an appendix.

Royal Botanic Gardens,
The Herbarium,
KEW, SURREY.

C. FISCHER.

Printed and Published by W. W. BELL, at the Methodist Publishing House, Madras, for the Indian Botanical Society—1932.

PRESIDENTIAL ADDRESS

BY

DR. T. EKAMBARAM

In addressing you this afternoon, I had the intention of placing before you the advance made in Botanical Study in India within the last few years before I gave you an account of the results obtained on work carried on in the Madras University Laboratory. But you had been given a fairly exhaustive account by the President of the Botanical Section of the Science Congress this morning. Still there is one point which cannot be passed over. In the citation of work in the different parts of India, it is surprising that Madras had not attracted Dr. Chaudhuri's attention and I feel I must supplement this omission. If you will permit me I wish to point out that long before most of the Universities in Upper India started, Botanical work was being carried on in Madras by Dr. Bourne and Prof. Fyson and his co-workers. In the early life of the Botanical Section of Indian Science Congress, most of the papers contributed came from Madras. But apart from this, the point that is of greater interest to this Society is that the Journal of the Society had its birth in Madras and it was mainly due to the enthusiasm of Prof. Fyson. I need not mention the great influence the Journal has on the advance of Botanical work in India.

While addressing the Botanical section of the Science Congress last year, I pointed out that our knowledge of the relation between the working of the root system and its environment was limited. I drew particular attention to two points. One was as to the effects of changes in the composition of the soil atmosphere and the other was the possibility of oxygen supply from the shoot system to the root system. Work carried out in the Research laboratories of the Madras University throws light on some points.

The gas-water system of the soil is a fluctuating and not a static system. The fluctuation in the water system is gradual and extends over a long period. But in the gas system, the fluctuations are of greater magnitude and also of diurnal periodicity. The metabolic activity of the roots of plants and of the soil organisms tend to decrease the O_2 concentration and increase the CO_2 concentration. The physical factors such as diffusion and

mass movement tend constantly to counteract the former. It is the relative intensity of these two processes that determines the composition of the soil gasses at any moment.

A method was deviced by which the dynamic system under which the roots of a plant normally work in the soil can be imitated under experimental conditions. By this method, it was possible to control the composition of root atmosphere by controlling the extent of its communication with the external atmosphere.

I do not wish to place before you at present the details of the data obtained. Let me draw your attention to certain main features of the results. These can be brought under three headings.

Firstly I will deal with the change in the composition of the root atmosphere when all connection with the external atmosphere is cut off. There is a fairly regular increase in CO_2 concentration and a fall in O_2 concentration due to respiration of the roots. The rate of increase or fall in CO_2 or O_2 decreases with time, that is to say the intensity of respiration shows a gradual fall from the outset. But the rate of decrease is increased after a critical concentration of the two gasses is reached. This turning point is of importance as its effect is seen on other functions of the roots as well.

If the root atmosphere is now placed in communication with the external atmosphere, the rate of respiration gradually increases till it settles down at a more or less uniform rate. This reversibility is possible only within certain limits of concentration of the two gasses. Beyond this limit, the roots are injured, they turn brown and eventually die.

The second aspect is the evidence that is made available as regards the supply of oxygen to the roots by the shoot system. The data for the actual composition of the gasses round the roots at any time show that the sum total of the CO_2 and O_2 percentages varies within small limits round about 21, that is the same as in the atmosphere. But that this similarity is only apparent will be brought out by the following considerations. As the CO_2 concentration increases, part of the gas produced will go into solution in the water round the roots and part will diffuse through the tissues. So the figure for CO_2 concentration as obtained by actual analysis will be resultant between addition by respiration and loss by solution and diffusion. In the case of oxygen, the position is that O_2 in solution in the water will escape into the gaseous phase to a certain extent and there is the possibility of diffusion inwards through the tissues. Let us consider one such

analysis. According to the actual figures obtained by analysis, the amount of CO_2 given off is equivalent to the amount of O_2 used up. But the real equation will be something approximating to this:

$$CO_2 + O_2 = (A + X - Y - Z) + (B - C + D + E) = 21$$

where A is the initial amount of CO_2, X is the amount produced by respiration, Y the amount lost by solution and Z the amount lost by diffusion. B will be the initial amount of oxygen, C, quantity lost during respiration, D, quantity added by escape from solution and E, quantity added by diffusion. Since $A+X+B-C=21$, $Y+Z$ must be equal to $D+E$. Because of the difference in the solubility of the two gasses, Y will be greater than D. So it appears that a larger volume of O_2 enters the roots from the shoot system than the CO_2 that may diffuse out through the same path. Apart from the quantitive relations for which there are not enough data available, it is evident that more CO_2 is produced than can be accounted for by the loss of O_2 from the root atmosphere. The excess O_2 that is thus used for respiration can come in only from the shoot system. Proof of such a supply of O_2 was obtained in one instance. When the root atmosphere had reached certain concentrations of the two gasses, a small quantity of water was introduced into the bottle. The immediate effect of this was that some quantity of CO_2 went into solution. Now the combined percentage of CO_2 and O_2 was much less than 21. After 24 hours, it was found that both the CO_2 and O_2 percentages had increased. That is to say, a quantity of O_2 bigger than what was used up for respiration during the 24 hours had diffused into the bottle. This has been recorded in the case of each of the three plants used in this study. The total percentage of CO_2 and O_2 came back to 21 in the course of 48 hours after the introduction of water, with a definite excess of oxygen. I need not say that very careful precautions were taken to prevent leakage through stoppers and connections.

The third aspect of the results obtained is the effect of the changes in the composition of the root atmosphere on transpiration. It was mentioned earlier that more or less uniform concentrations of the two gasses obtain when the root atmosphere is kept in communication with the outside, and that when the connection was cut off, CO_2 concentration increases and that of O_2 falls. During the first three days after the cutting off of communication with outside, transpiration shows a tendency to increase gradually till a maximum rate is reached. This maximum rate coincides

with the critical concentrations of the two gasses noted before in connection with respiration. When the change in the concentration of the two gasses passes this limit, transpiration rate falls as was the case with respiration also. The next effect observed is the wilting of the experimental plant during the day while the control is quite normal. The plant at this stage is capable of recovery and the next morning the leaves get turgid. At this stage, then, the rate of absorption by the roots is lowered and is not able to replace water lost during day time but the deficit is made good in the latter part of the day. The stomata also show partial closure as compared with the control. If the root atmosphere is now placed in communication with the outside, a complete recovery takes place. The next stage is one when the plant does not recover from the wilting condition. The roots show browning indicating death.

These results bring out one important point and that is that there is a critical concentration of CO_2 and of O_2 at which a maximum rate of transpiration is reached. It is remarkable that below this critical concentration, that is when there is more oxygen and less of carpon di-oxide in the bottle the rate is lower. Putting in other words, one of these two gasses acts as a stimulant and furthers transpiration while a certain concentration is being reached. This critical concentration varies in the case of each of the three plants referred to. This stimulatory effect or that there is an optimum concentration of the gases at which transpiration is at a maximum is, I believe, brought out prominently by these studies.

The composition of the root atmosphere was manipulated so that this critical concentration was reached either when going up from that of the atmospheric air or coming down towards it. On each occasion the rise in the rate of transpiration was noted.

Though further confirmation is necessary as the number of plants worked with so far is few, there is an indication that this critical concentration is nearer that of the atmospheric air in the case of herbaceous or shallow rooted plants. Whereas it is further away in shrubby or deep rooted plants.

Whether this maximum transpiration is brought about by an increased absorption or by a change in the leaf cells to accelerate transpiration is a point of interest for further investigation.

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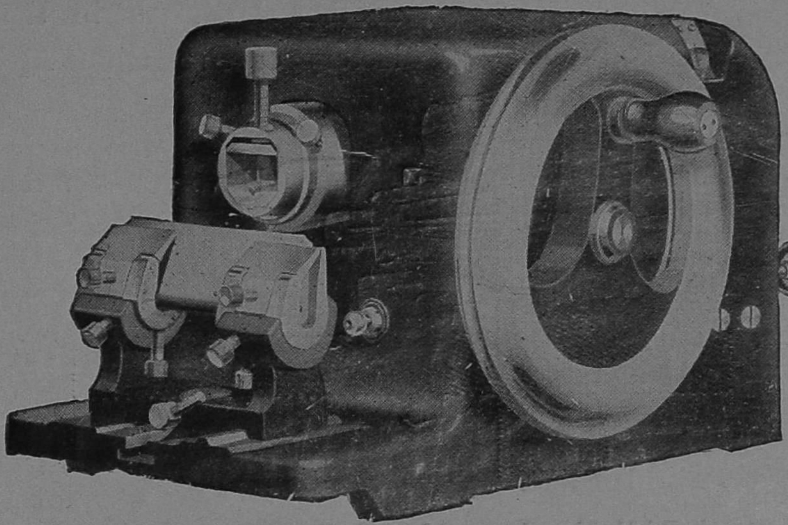

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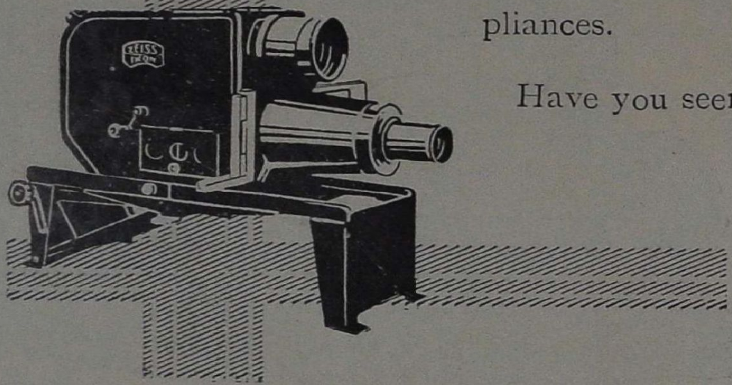

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Original papers should conclude with a summary drawing attention to the main facts and conclusions. References to literature cited should, as far as possible, be complete and must be carefully verified. Where a bibliography is given at the end of the paper it should be arranged alphabetically under authors' names.

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Contents of this Number.

PAGE

ORIGINAL PAPERS :

Malhotra, R. C. The Influence of Ultra-Violet Rays, X-rays and Temperature on the Germination of Zea Mays 1

Blatter, E., S.J., Ph.D., F.L.S. Plants from Basra in Mesopotamia 28

Fyson, P. F. Notes on Four Species of Flowering Plants from the South Indian Highlands ... 48

Boergesen, F. Some Indian Green and Brown Algae Especially from the Shores of the Presidency of Bombay—II 51

Amar Chand Joshi, M.Sc. Vivipary in Atriplex Crassifolia and Sueda Fruticosa 71

Amar Chand Joshi, M.Sc. Structure, Arrangement and Course of Vascular Bundles in the Stem and Leaves of Heptapleurum Venulosum Seem ... 73

Banerji, I., M.Sc. Chromosome Numbers of Indian Crop Plants 82

Kashyap, S. R. The Gametophyte of Equisetum... 86

NOTES :

A Note on the Opening of the Flowers of Portulaca Tuberosa. A. B. SARAN, M.Sc. 89

A Simple Method of Illustrating Mendelian Inheritance. B. B. MUNDKUR 92

REVIEWS :

The Flowering Plants of Madras City and its Immediate Neighbourhood. P. V. MAYURANATHAN 94

Iconum Botanicarum Index Londinensis. O. STAPF 95

The Indian Species of the Genus Caralluma. F. H. GRAVELY AND P. V. MAYURANATHAN 96

F[illegible] of Siam. A. C. J. 97

PRESIDENTIAL ADDRESS, 1931 99